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THE RELIABILITY OF THE ELECTRICAL DIAGNOSIS OF TETANY

WITH ESPECIAL CONSIDERATION OF THE ELECTRICAL VALUES FOUND IN NORMAL CHILDREN *

JAMES B. HOLMES, M.D.
BALTIMORE

The first electrical diagnoses of tetany in children were made on well marked clinical cases. The electrical values obtained in these were much lower than those found in children free from tetany. It was later discovered that some children who showed no clinical evidences of tetany gave electrical values nearly if not quite so low as those found in cases of clinical tetany. Such children were said to suffer from latent tetany, the diagnosis being based wholly on the electrical reactions.[1]

With this extension of the conception of tetany as an active and as a latent disease of infancy and childhood, the diagnosis of it has, especially with older children, come to rest on a less secure foundation. There have been no electrical standards established for normal children beyond the period of infancy, it having apparently been assumed that the values established for infants are applicable to older children as well. A study of the reactions in older children shows almost at once that this assumption is unjustifiable.

Even with infants, also, the determination of what is normal and what is abnormal offers at times great difficulties. Therefore, I have studied the reactions of infants and older children with and without tetany in order to determine the reliability of the electrical diagnosis of this disease and, especially with older children, to establish the standards for the normal and the deviations from this which enable us to recognize the presence of tetany.

The Development of the Conception of Tetany.—Many of the symptoms which we now recognize as belonging to tetany were first described in infants that were teething. Increased irritability, abnormal

* Submitted for publication April 15, 1916.

* From the Harriet Lane Home and from the Department of Pediatrics of the Johns Hopkins University.

1. The chief justification for this conception and diagnosis of latent tetany is to be found in the fact that some of these children with low electrical values later develop unmistakable clinical symptoms of tetany.

contractions of the muscles, transient spasms, and, finally, convulsions, were thought to be more or less normal accompaniments of dentition. It was not until a century ago that physicians studied certain of these symptoms more carefully and began to recognize their abnormal character. One by one they were described, at first as independent entities and then as different manifestations of one underlying disease.

James Hamilton[2] in 1809 gave a beautiful description of spasm of the larynx and spoke of it as the most formidable symptom, except convulsions, which occurs during dentition. In 1816 George Kellie[3] of Leith wrote at some length on a form of swelling of the backs of the hands and feet and on a spasmodic affection of the thumbs and toes which commonly accompanied it. Underwood, he said, had earlier described this condition, regarding it as of no importance, since it went away upon the eruption of the teeth; but to Kellie it seemed rather to constitute "a part of a disease of a somewhat more serious and striking nature." In the next year James Johnson[4] of Philadelphia applied the term "carpopedal spasm" to this condition. It occurred, in his case, in association with transient spasmodic affections of the muscles of respiration.

In 1819 J. Cheyne[5] differentiated clearly between hydrocephalus and laryngospasm. He said: "The pathognomonick of this disease is a crowing inspiration, with purple complexion, not followed by cough. In some cases . . . attended, not merely with a permanent clenching of the hand upon the thumb, but also with a very remarkable fixed spasm of the toes, particularly the great toe, which gives a look of swelled deformity to the upper part of the foot." He spoke also of the associated convulsions.

John North[6] referred to the syndrome as one generally recognized, and Marshall Hall[7] described the symptoms in a complete manner and attributed their appearance to reflex irritation of the central nervous system from teething and the presence of indigestible food residue in the gastro-intestinal tract.

The names of the earlier workers are, it will be noted, all British or American. Their views seem to have had little influence on French teaching; they were, however, accepted in Germany and there further elaborated. Then attention became centered upon details of symptomatology and etiology and the broader view that grouped together under

2. Hamilton, James: Hints on the Treatment of the Principal Diseases of Infants, 1813.

3. Kellie, George: Notes on the Swelling of the Tops of the Hands and Feet, etc., Edinburgh Med. and Surg. Jour., 1816.

4. Johnson, James: Med.-Chir. Jour., Philadelphia, 1817, iii, 448.

5. Cheyne, J.: Essays on Hydrocephalus, or Water in the Brain, Ed. 2, 1819.

6. North, John: Practical Observations on the Convulsions of Infants, 1826.

7. Hall, Marshall: Diseases and Derangements of the Nervous System, 1842.

one head the conditions of laryngospasm and nonepileptic convulsions of childhood was almost forgotten for many years.

It is to Cheadle[8] and those working with him that we owe the reestablishment of the old views of tetany after they had remained in obscurity for many years. "Laryngospasmus, tetany and convulsions," said Cheadle in 1887, "are different expressions of the same constitutional morbid state, are associated especially with the first two years of life, with the period of rickets and with the period of dentition." He designated this morbid constitution as "a state of erethism," in which the central nervous system is in a condition of abnormal excitability. He considered this condition and tetany of adults one and the same disease, with, however, this difference: in the adult muscular contraction predominates in the picture, in childhood convulsions and laryngospasm predominate. Abercrombie[9] had noted "facial irritability" as a new symptom. Stewart,[10] an American, reported in 1889 the presence of increased electrical excitability (Erb's phenomenon) in the tetany of childhood.

Escherich[11] (1890) found that mechanical excitability of the nerves, especially the facial phenomenon, was regularly present in laryngospasm, and that Trousseau's sign and spontaneous contractions seldom failed. In association with von Wagner, he demonstrated at that time the presence in the infant of galvanic electrical hyperirritability of the nerves, similar to that found in the tetany of adults. Moreover, he found that this electrical hyperirritability came and went with the attacks of laryngospasm and that as the attack passed away the spontaneous contractures disappeared first, then the Trousseau phenomenon, next the laryngospasm, and finally the electrical hyperexcitability.

The views of Escherich met at first with much opposition, but they were soon confirmed by reports from other sources. In the next year (1891) Escherich reported his observations on nearly three hundred cases. Since that time the contributions have dealt, for the most part, with details of diagnosis, etiology and treatment, and need not be mentioned here.

The Electrical Diagnosis of Tetany.—The presence of increased electrical excitability in the nerves of adults suffering from tetany—the so-called Erb's phenomenon—was noted by Erb in 1878. The first

8. Cheadle: Pathology and Treatment of Laryngismus, Tetany and Convulsions, Lancet, London, 1887, i, 919.

9. Abercrombie: On Tetany in Young Children, London, 1880.

10. Stewart: Tetany, Am. Jour. Sc., December, 1889, cited after Escherich.

11. Escherich: Idiopathische Tetanie im Kindesalter, Wien klin. Wchnschr., 1890, iii, 769; Begriff und Vorkommen der Tetanie im Kindesalter, Berl. klin. Wchnschr., 1897, xxxiv, 861; Die Tetanie der Kinder, Vienna and Leipsic, 1909, p. 10.

report of the presence of similar heightened electrical excitability in children suffering from tetany came from the American physician, Stewart, in 1889.

The first extensive study of Erb's phenomenon in the tetany of children under three years of age was made in the clinic at Graz, in 1890, by Escherich and his associate von Wagner. Ganghofner,[12] Hauser,[13] Kalischer,[14] Burkhardt,[15] von Pirquet,[16] and others supplemented these studies. The nerves most commonly selected for examination have been the median nerve (stimulated in the bicipital fossa) and the peroneal nerve (stimulated near the head of the fibula—Erb's point). The earlier investigators anesthetized their patients, thinking that restlessness might interfere with satisfactory readings; later workers have not found this necessary. As the change in the electrical excitability of the nerves in tetany is a general one, affecting all the peripheral nerves,[17] it is possible, by examining one nerve, to determine the condition of the peripheral nervous system as a whole. It is necessary, however, to have some table of the values to be expected in normal children for use as a comparison.

Stintzing[18] in 1886 prepared tables showing the range of values found for each of the peripheral nerves in normal adults, but no similar table has been compiled for infants and children. The Stintzing tables for adults give the cathodal closing (C. C. C.) values only. That the determination of the cathodal closing value alone is not sufficient in the case of infants and young children is shown by a brief review of the development of our knowledge of galvanic electrical reactions in children. The work of Escherich, Ganghofner, Burkhardt, Kalischer, Thiemich and Mann,[19] and finally of von Pirquet, is of especial interest.

Escherich found what he considered abnormally low values for the C. C. C. (cathodal closing contraction) and the C. C. Te. (cathodal closing tetanus) in the few patients he examined in 1890. He spoke also of the occasional appearance of anodal opening tetanus, though the strength of current required to produce it was not given.

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12. Ganghofner: Ueber Tetanie im Kindesalter, Ztschr. f. Heilk., 1891, xii, 447.
13. Hauser: Ueber Tetanie der Kinder, Berl. med. Wchnschr., 1896, xxxiii,782.
14. Kalischer: Jahrb. f. Kinderh., 1896, xlii, 386.
15. Burkhardt: Die Tetanie im Kindesalter, Cor.—Bl. f. schweiz. Aerzte, 1893, xxiii, 23.
16. Von Pirquet: Die Anodische Uebererregbarkeit der Säuglinge, Wien. med. Wchnschr., 1907, lvii, 14.
17. This assertion, though commonly accepted, is questioned by some authors; consult Borrutau-Mann: Handbuch der electro-medizinische Technic, Leipzig, 1909, ii, 384.
18. Stintzing: Ueber elektrodiagnostische Grenzwerte, Deutsch. Arch. f. klin. Med., 1886, xxxix, 76.
19. Thiemich and Mann: Monatschr. f. Psychiat. u. Neurol., 1899, vii, 14; Jahrb. f. Kinderh., 1900, li, 99.

Ganghofner examined thirteen cases and found the cathodal closing values low in all, with a return to higher values as the symptoms of tetany vanished.

Burkhardt in 1893 reported a typical case of tetany in a 2½ year old child, with increased galvanic excitability.

Hauser in 1896 was the first to dispense with chloroform anesthesia. He examined 280 children, ages not given, with various diseases, and testing the median and ulner nerves for the cathodal closing contraction and cathodal closing tetanus, found C. C. C. values ranging from 0.2 to 0.5 milliamperes and C. C. Te. from a few ma. to 16 ma. As a result of his study he asserted that increased electrical excitability of the nerves was the most constant and important symptom of tetany. Oddly enough, he did not observe this phenomenon in most of the cases of laryngospasm that he examined. Kalischer reported similar findings in the same year.

In 1897 Escherich published the results of later examinations made by him without anesthesia. He found what he considered to be an increased electrical excitability in all cases of tetany examined by him, and found, also, that this heightened electrical excitability preceded the appearance of spasms, and lasted weeks or months after these had disappeared. Especially important appeared to him the lowering of the C. C. Te. values. The nerve examined in this study is not mentioned.

In the same year (1897) Thiemich made an important contribution to the subject by determining what he considered the normal values for children in what we may call the tetany age, and by calling attention to the significance of the early appearance of cathodal *opening* contractions (C. O. C.). Stintzing had already determined the normal range of values for the cathodal closing contraction (C. C. C.) in adults. TheWestphals,[20] father and son, studying the C. C. C. only, had shown that much higher values obtain in newly born infants. Thiemich and Mann examined fifty-six children whom they believed free from tetany and, averaging their findings, obtained the following results:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
Children under 8 weeks of age.....	2.6	2.9	5.1	9.3
Children over 8 weeks of age.....	1.4	2.2	3.6	8.2

The nerve examined was the median, the point of stimulation being at the end of the bicipital fossa just above the bend of the elbow. The ages of the children were not given, nor were the actual findings from which the averages were obtained. There is evidence that the

20. Westphal, A.: Die electrischen Erregbarkeitsverhaltnisse des peripheren Nervensystems des Menschen im jugendlichen Zustande und ihre Beziehungen zu dem anatomischen Bau desselben, Arch. f. Psychiat., 1894, xxvi, 1; Westphal, C.: Neurol. Centralb., 1886, v, 6.

children were all under three years of age. Thiemich and Mann thus obtained results that were more precise than any that had previously been recorded.

They then examined children of this age who were suffering from tetany, latent and active, and recorded similarly the electrical values found in them. They noted, in addition to low values for the C. C. C. (cathodal closing contraction), a preponderance of A. O. C. < A. C. C., anodal opening contractions appearing with less current than anodal closing contractions, and especially the appearance of C. O. C. with a current of less than 5 ma.

This last observation, the appearance of C. O. C. under 5 ma., Thiemich thought characteristic of tetanoid conditions of the nervous system; indeed he emphatically insisted that such a reaction was necessary for the diagnosis of tetany.

Ganghofner in 1904 reported the results of a few examinations. In the main he confirmed Thiemich's conclusions, but he believed that cases of undoubted clinical tetany may exist in which the cathodal opening contraction may be above 5 ma. (C. O. C. > 5 ma.), and that he had seen children (ages not stated) in whom the C. O. C. occurred with a current less than 5 ma., yet who neither before nor after the examination ever presented any clinical signs of tetany.

In reviewing the reports of all the earlier observers the reader is struck with the fact that the ages of the children examined are rarely given. In some instances one may infer that the age was under three years, for example, in Thiemich and Mann's work; as a rule the reader is left in doubt. Much more precise is the statement of the next contributor of importance, von Pirquet.

Von Pirquet in 1907 made systematic and repeated examinations on twenty-four children in the infant section of the Vienna clinic, through periods ranging from one month to a year. The oldest of these children appears to have been under two years of age. Two of the twenty-four developed definite signs of clinical tetany at some time during the year. As the result of his study von Pirquet offered the following corrections to the work of Thiemich and Mann, and gave as normal values for infants under 2 years of age as follows:

C. C. C.	A. C. C.	A. O. C.	C. O. C.
3	> 5	> 5	> 5
(exceptionally 1 to 5)	or < 5		

These values were obtained from the peroneal nerve.[21] As is indicated, von Pirquet found that the value of the anodal closing contrac-

21. Von Pirquet stated that he made comparative studies on the peroneal and median nerves and that his results showed approximately equal values for the opening contractions on the two nerves, and distinctly lower values in the median nerve for closing contractions.

tion varied and that it often fluctuated from day to day. The anodal opening value, on the other hand, he found remarkably constant:

Von Pirquet drew the following conclusions:

1. Normal infants present only closing contractions under 5 ma. when examined with the galvanic current.

2. The appearance of an anodal opening contraction under 5 ma., when unaccompanied by a cathodal opening contraction or cathodal closing tetanus under 5 ma., is characteristic of a low grade of hyperexcitability that may be termed anodal hyperexcitability.

3. Anodal hyperexcitability is a precursor of cathodal hyperexcitability, which is indicated by the appearance of cathodal closing tetanus or a cathodal opening contraction under 5 ma.

This work is the last important contribution to the development of the subject. In addition to giving a more precise statement regarding the electrical values in children under 2 years of age, von Pirquet introduced the conception of anodal hyperexcitability. Anodal hyperexcitability, he found, preceded the appearance of cathodal hyperexcitability, accompanied it, and was present for a time after the disappearance of the latter. It was present during the late spring of one year in one half of the infants in the Vienna Hospital, and it was in this group that the two cases of clinical tetany appeared; therefore, he regarded this condition, anodal hyperexcitability, as a sign of latent tetany.[22] The development of active clinical, or manifest, tetany in his two cases was accompanied by the appearance of cathodal hyperexcitability (C. C. C. $<$ 5 ma.).

Von Pirquet stated distinctly that his observations were made upon infants. He believed that the values for normal infants are approximately those given by Thiemich and Mann for children in the first

22. The term "latent tetany" seems to have been first used by Erb. In his chapter on Tetany in Ziemssen's Handbuch it is stated that repeated examination by him of two cases had shown that there existed a condition of increased electrical excitability, a fact earlier affirmed by several observers, notably by Benedict and Kussmahl; and that "the greatest increase of excitability coincided with the time of the best marked and most frequent attacks of tetany and there was a decrease in the excitability as they became less frequent; and finally, when the patient had completely recovered, the electrical excitability was found to be approximately normal. A distinct parallelism could thus be demonstrated to exist between the occurrence of spasms and the increase of electrical excitability" . . . and, it was added, as a footnote: "It is probable that exact electrical investigation, as well as Trousseau's symptom, would afford a means of recognizing a *latent condition of the disease, or that condition in which no attacks of tetany are present, though the disease is not entirely cured. The persistent increase of faradic, and especially of galvanic, excitability would constitute the characteristic symptoms of this condition.*" (The italics are mine.)

In the same paper it was observed that "the period of latency, in particular, may last for a long time, and apparent relapses are certainly often only indicative of the fact that the disease had not entirely run its course."

eight weeks of life, and that the values given by Thiemich and Mann for children over 8 weeks of age are too low for children between 8 weeks and 24 months of age. He gave as the values for normal children under two years of age:

C. C. C.	A. C. C.	A. O. C.	C. O. C.
3	>5	>5	>5
(exceptionally 1 to 5)	or <5		

No mention was made of the values for children over two years of age.

Thiemich had determined the values in cases of tetany in children under three years of age, and for these had given the formula:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
Tetany, manifest....	0.63	1.14	0.55	1.94

These figures were obtained by averaging the actual values found. They stand in sharp contrast with the normal values as given by Thiemich for children over 8 weeks of age, and in still greater contrast with the normal values given by von Pirquet for infants under 2 years of age.

The values found in Thiemich's cases of latent tetany in children were:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
Tetany, latent.....	0.70	1.45	0.95	2.93

Here, also, neither the highest nor the lowest values actually found are given, but only the average of them all. It will be noticed that Thiemich's phenomenon, or the occurrence of cathodal opening contractions under 5 ma., is present, and the anodal opening is lower than the anodal closing value, in the formulas both for latent and active tetany. Taken in all, the values of the formulas given by Thiemich for latent and active tetany are so nearly alike that we may regard the two formulas as practically the same. There is a very great difference between them and the normal and very little danger of confusion.

Von Pirquet's observations, however, made it apparent that in cases of latent tetany particularly figures not deviating so far from the normal are to be expected and, as outlined above, he identified anodal hyperexcitability with latent tetany, and cathodal excitability with active, manifest tetany. However, he stated distinctly that his observations were made upon infants.

Many writers have not hesitated to utilize the data obtained upon infants and young children and consider them applicable to older children. Yanase,[23] for example, working in Vienna, applied the formulas obtaining in infancy to children of 5 and even 8 years of age, and finding in them anodal, and occasionally cathodal, hyperexcitability,

23. Yanase: Jahrb. f. Kinderh., 1908, lxvii, 57.

made diagnoses of tetany. Peritz[24] (1912) says specifically that Escherich's value of 5 ma., for the anodal opening contraction as an expression of heightened excitability certainly applies to older children; and, further, that the early appearance of anodal opening contractions (that is, A. O. C. <5 ma.) seems pathognomonic of tetany in older children.

More recently Sedgwick[25] has examined the mothers of children that he thought spasmophilic and has been surprised at finding in the mothers values that compared with the formulas of infancy are abnormally low. Low values, as tested by the same standard, were found also in fathers and older brothers and sisters of such children. From these findings he has drawn far-reaching conclusions regarding spasmophilic families, in which the hereditary taint manifests itself in the children in the form of repeated absences or mild epileptiform attacks.

Now Stintzing has shown us that the value for the C. C. C. (cathodal closing contraction) for the peroneal nerve in adults ranges from 0.2 ma., which he calls the lower limiting value, to 2 ma., the higher limiting value. The Westphals, Mann and Thiemich, von Pirquet and others have shown that much higher values are to be expected in normal infants and, indeed, in children up to the third year. It is evident that a transition from the high normal values of infancy to the relatively low values of adult life occurs somewhere between the second year of life and puberty. When and how these changes occur has not been hitherto reported.

The recent clinical development of the conception of latent tetany forces this lack of knowledge upon our attention. The clinician who attempts to diagnosticate tetany or latent tetany in older children at once finds himself hampered by the inadequacy of published data regarding the course of galvanic excitability of the peripheral nerves in normal children. Ibrahim[26] has well said, in criticizing Sedgwick's paper on repeated absences, that it cannot be accepted as proved that the values that are pathognomonic for infants have the same diagnostic importance in older children and adults. Control examinations of normal children are very much to be desired.

It has seemed wise for these reasons to investigate the range of galvanic electrical values in a large number of children from birth up to thirteen years of age, and to record not only the average values, but also the highest and lowest values found in normal children of each year of life, together with any changes in the reactions that might be of importance.

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24. Peritz: Nervenkrankheiten, Berlin, 1912, p. 444.
25. Sedgwick, Julius Parker: Spasmophilia with Especial Reference to Familial Reactions and Repeated Absences, Am. Jour. Dis. Child., 1914, vii, 140.
26. Ibrahim: Ztschr. f. Kinderh., 1914, Referate, viii, 22.

The results of such an examination of a large number of average dispensary and hospital patients are herewith presented in tabular form.

The clinical material for examination was obtained from all patients admitted to the wards of the Harriet Lane Home from November, 1913, to April, 1914. These patients were tested as part of the first routine examination, and the test was repeated, as a rule, at intervals of a week or ten days thereafter during the patient's stay in the hospital. As many cases as time permitted were selected at random each day from the children in the outpatient department, and when a patient had been once tested an effort was made to repeat the test upon several subsequent visits. This practice applied also to former hospital patients.

Such patients are admittedly not normal children in the strictest sense of the word. The expression "normal children" is here used to designate those entirely free from evidences of clinical or latent tetany. Some of them were perfectly normal; some of them were brought for minor ailments, while others were suffering from, or convalescent from, severe illnesses. A few were epileptic or mentally retarded. There was no reason to suppose that any were not normal so far as their electrical reactions were concerned.

Four hundred and thirty-four patients were examined in all. Thirty-four of these were felt to be definitely abnormal, from the point of view of the study in hand, and were excluded from the present tabulation.

Of the thirty-four patients excluded from tabulation, thirteen were patients with latent or active tetany. The majority of them were admitted to the hospital for further study. In the other twenty-one cases the values obtained upon examination (first or subsequent) differed so widely from those of the ordinary child of the same age that it was thought best to exclude them from the series. Among them were three cases of hydrocephalus (with spasticity of the lower extremities) and other cases of abnormalities of the central nervous system, some of which will be discussed at the close of the paper.

The Technic of Examination.—With the child on his back, the examiner stood on the child's right and supporting the right knee and leg with his left hand, applied the stimulating electrode with his right hand.[27]

An assistant, standing opposite the examiner and holding the indifferent electrode in place on the epigastrium with one hand, controlled the electrical apparatus with the other.

27. With the examiner standing in the position here described, slight movements of the foot, toes and tendons may be seen, and minimal contractions in the muscles of the lower leg may be felt, particularly in infants, by the fingers of the left hand as they rest on them. Voluntary movement of the leg is also restrained.

The apparatus was a silver chlorid battery of thirty-five cells, with the amperemeter in the direct circuit and reading fifths up to ten milliamperes.

The stimulating electrode consisted of a spherical metal ball of 1 cm. diameter mounted on a wooden handle bearing a make-and-break key, and the indifferent electrode of a metal disk 4 cm. in diameter. Both electrodes were covered with a thin layer of sponge to retain moisture and were moistened in warm water for use. In young infants the stimulating electrode was held firmly in the popliteal space—maximum contractions for minimal strength of current may be thus obtained in infants. In well-grown infants, and in children over 1 year of age, the point of maximum sensitiveness (Erb's point for the peroneal nerve) was sought, and being found, was retained throughout the examination.

The cathodal closing values were first sought by using a current sufficient to provoke a contraction. The strength of current was then diminished as rapidly as possible until contractions just ceased to appear. The reading at the appearance of minimal contractions, the needle always being allowed to come to rest, was recorded.

After waiting a few moments the anodal values were sought, beginning, as a rule, with about 5 ma. of current, diminishing it, and noting, as before, at what point minimal contractions appeared.

After again waiting, the cathodal opening value was similarly sought. The early appearance of cathodal closing tetanus sometimes prevents one obtaining a cathodal opening contraction; and in such cases cathodal closing tetanus alone was recorded.

The facial phenomenon (Chvostek), if present, was recorded in terms of its grade.[28]

In no case was an anesthetic used and, save in two instances, it was never found impossible so to accustom the child to the procedure that a successful examination was possible. Infants were frequently examined while sleeping, without awakening them.

Rickets.—Tetany is no longer regarded as a symptom of rickets; but both are generally believed to be related in some way to disturbances in calcium metabolism. It is therefore necessary to review the conditions under which rickets appeared in the 400 children whose electrical values are here tabulated.

The number of cases (thirty-six) in which the presence of rickets was noted as other than the principal diagnosis—it was recorded as the principal diagnosis in seventeen cases—may appear small in comparison with the total number of cases tabulated (400); but this seeming disparity disappears when comparison is made with the number of individuals (100) examined between the sixth month and the third year, the period of active rickets. Then, too, the majority of cases of clinical tetany found during the period of study (see above) also presented signs of rickets, and the exclusion of these from the present table further reduces the percentage of rickets recorded therein. Possibly more cases suffered from rickets in some slight degree but not sufficiently to be clinically recognizable.

Examination of those individual cases in each age group which gave electrical values below the average for that group, showed that rickets was present with frequency only in Group 1 to 6 months and Group 1 to 2 years. In the former group it was present in 37 per cent. of the cases showing electrical values

28. Escherich records the Chvostek phenomenon in three grades, thus: Grade 1: Slight twitching at the angle of the mouth or of a small muscle bundle in the nose or forehead, following tapping with a percussion hammer or bent finger on a point midway between the pons zygomaticus and the angle of the mouth, over the facial plexus; Grade 2: A strong lightning-like twitch at the corner of the mouth, alae nasi, orbicularis, or frontalis muscles; Grade 3: A definite twitch in all the muscles supplied by the facial nerve upon tapping over it in front of the external auditory canal.

notably lower than the average. In the latter group it was present in 65 per cent. of the cases showing noticeably low values, and the lowest values included in the statistics for that group occurred in three cases of florid rickets.

In examining the tabulated results it is seen that the children are grouped according to age, and the number of children examined in each age group is given, together with the total number of examinations. The values obtained on galvanic electrical examination are presented

TABLE 1.—AVERAGE ELECTRICAL VALUES OF NORMAL CHILDREN OF DIFFERENT AGES

Age of Child, Years	Number of Children Examined	Average of Values Obtained in Normal Children				A. O. C. Less than A. C. C. %	Chvostek Phen., %	Total Number Examined
		C. C. C.	A. C. C.	A. O. C.	C. O. C.			
Under 1 mo.	29	>5	>5	>5	>5	0	..	39
1 to 6 mos.	56	3.9	4.9	>5	>5	8	0	157
½ to 1	38	3.3	4.7	4.6	>5	20	0	68
1 to 2	41	2.9	4.6	4.6	>5	36	0	78
2 to 3	20	2.5	4.2	4.3	>5	30	5	31
3 to 4	24	2.3	4.2	4.2	>5	40	0	42
4 to 5	20	2.1	3.8	4.1	>5	40	0	25
5 to 6	22	1.9	4.1	3.7	>5	67	14	43
6 to 7	20	1.8	3.9	3.0	4.9	75	5	36
7 to 8	20	1.9	3.7	3.2	4.9	65	5	22
8 to 9	30	1.7	3.9	3.5	>5	60	16	41
9 to 10	20	1.8	3.8	3.2	4.9	55	25	38
10 to 11	20	1.8	3.6	3.5	4.9	50	20	28
11 to 12	20	1.5	3.5	3.1	5.0	40	25	24
12 to 13	20	1.7	3.6	2.3	5.0	55	20	28

under three heads: (1) the average values;[29] (2) the highest values discovered, provided those did not exceed 5 ma.; and (3) the lowest values found in children who did not present other signs of latent

29. In computing the average values, values >5 ma. were treated as 5 ma, and the appearance of cathodal closing tetanus was regarded as the equivalent of a cathodal opening contraction of the same number of milliamperes; that is, C. C. Te = 4.2 ma. was regarded as the equivalent of C. O. C. = 4.2 ma. Now since A. C. C. >5, for example, may, in a given instance, stand for A. C. >6 or 8 or 10, it is clear that such a method of computing may give an unduly low average value, particularly in infants, in whom the A. O. C. and C. O. C. values often range far above 5 ma.; yet, since it is not desirable to test for contractions with current of greater strength than 5 ma., some such method of computing must be employed. In the data for older children this source of error is practically excluded, since in them the prevailing values are below 5 ma.

tetany. Under each group is indicated also the frequency with which there appeared anodal opening contraction with a current less than that causing anodal closing contractions, that is A. O. C. < A. C. C., the so-called anodal hyperexcitability of von Pirquet.[30] The number of cases in which a positive Chvostek phenomenon appeared is also noted.

These are the average electrical values of normal children, obtained and computed in the manner described. Stintzing has shown, however,

TABLE 2.—Extremes of Electrical Values in Apparently Normal Children

Age, Years	Lowest Values Found in Apparently Normal Children				Highest Values			
	C. C. C.	A. C. C.	A. O. C.	C. O. C.	C. C. C.	A. C. C.	A. O. C.	C. O. C.
Under 1 mo.	3	4.2	>5	>5	>5	>5	>5	>5
1 to 6 mos.	1.6	3.4	>5	>5	>5	>5	>5	>5
½ to 1	1.9	2.0	2.9	>5	>5	>5	>5	>5
1 to 2	1.2	2.4	2.1	>5	>5	>5	>5	>5
2 to 3	1.2	2.8	2.5	>5	>5	>5	>5	>5
3 to 4	1.2	2.9	2.4	>5	4.5	>5	>5	>5
4 to 5	1.4	2.8	2.7	>5	2.9	>5	>5	>5
5 to 6	0.5	2.1	1.4	3.8	>5	>5	>5	>5
6 to 7	1.0	2.6	1.8	4.3	3.0	>5	>5	>5
7 to 8	1.1	2.2	1.7	4.9	2.8	>5	>5	>5
8 to 9	0.5	1.9	1.5	3.8	3.0	>5	>5	>5
9 to 10	1.1	2.7	2.1	4.7	3.0	5.0	>5	>5
10 to 11	1.1	2.0	2.0	4.7	3.0	>5	>5	>5
11 to 12	0.9	1.8	2.0	4.9	3.3	>5	>5	>5
12 to 13	0.3	1.8	1.5	>5	1.7	>5	>5	>5

how wide may be the range of electrical values in normal adults—the C. C. C. may be 0.2 to 2 ma. for the peroneal nerve at Erb's point, the average being 1 ma. There are analogous variations in infants and children. They may not be so great, but they exist.

There are presented here two other columns of figures, one showing the highest values discovered during the examination of the children in each age group, the other showing the lowest values found in children that were not subjects of active or latent tetany, so far as could be determined by careful examination, questioning, and by the observations of their subsequent symptoms.

30. See page 7.

It is difficult to know what interpretation to put on low electrical reactions in apparently normal children. There was sometimes found one figure, for example a C. C. C. value, which was very low, while all the other figures were high; but in general when one figure was high all were high, and vice versa. The low figures in Table 2 were found in individual patients, and are not compiled from isolated observations in several patients.

It can be understood that it is often exceedingly difficult to differentiate between the normal and the abnormal by electrical reactions alone, and it is frequently impossible to determine at the first examination whether younger children presenting low values are really suffering from a low-grade latent tetany. Later on, illustrative cases will be given, but the danger of including improper cases in the table of averages has led me to discard all those with unusual, isolated and unexplained low electrical values.

From these tables certain conclusions stand out clearly:

1. There is a gradual transition from the high electrical values of early infancy to the relatively low values of adult life.

2. Values below 5 ma., other than cathodal closing values, are rare in the first six months of life, but appear with increasing frequency thereafter.

3. Cathodal opening contractions with a current of less strength than 5 ma. are of infrequent appearance in normal children of any age; they probably do not occur in normal children under 5 years of age. The same may be said of cathodal closing tetanus. The occasional appearance of either after 5 years is not, per se, pathognomonic of tetany, but such children should be carefully examined for other evidences of tetany.

4. The presence of anodal opening contractions with a current less than that causing anodal closing contractions and under 5 ma. (anodal hyperexcitability) occurs with gradually increasing frequency from the first half-year of life upward, reaching its maximum frequency at 6 or 7 years. The infrequency of its occurrence in infants under 6 and 12 months of age (incidence 8 and 20 per cent., respectively) renders its appearance in them of considerable diagnostic importance, since this inversion of the usual sequence, as has been shown by others, may be, in cases of tetany, a forerunner of that cathodal hyperexcitability which usually accompanies manifest tetany. After the second or third year the presence of anodal opening contractions under 5 ma. in itself affords little help in diagnosis.

5. The facial phenomenon (Chvostek) is rarely met with in normal children under 5 years of age; it appears with increasing frequency thereafter.

6. There appears to be a rather abrupt transition toward adult values at the fifth to sixth year of life. In the age group 5 to 6 it is seen (*a*) that much lower values than hitherto were obtained in apparently normal cases; (*b*) that inversion of the earlier relation of anodal opening and anodal closing contractions appears in the formula of aver-

age values, and (*c*) that the facial phenomenon (Chvostek) appears with much increased frequency.

Knowing the galvanic electrical values that may be expected in normal children in each year of life, one can now proceed with some confidence to a critical examination of the electrical reactions that have been held by various authors to indicate the presence of tetany in infancy and childhood.

It should be emphasized that one low electrical value, no matter how low, is not in itself evidence of tetany. This is true especially of a low cathodal closing value. A low anodal value is of greater importance. If such appears to be present, the fact should be verified by a second examination a few minutes later. In clearly defined cases of tetany all values will, as a rule, be lower than usual.

In his earlier studies (1890 and 1897) Escherich stated that he found increased electrical excitability in all cases of tetany examined by him, and emphasized the early appearing cathodal closing tetanus as evidence of this. He considered hyperexcitability of the peripheral nerves the most important symptom of infantile tetany, which he defined as tetany occurring in children under 3 years of age, and said that at this age if electrical hyperexcitability were absent the diagnosis of infantile convulsions due to tetany could not be made, while certain conclusive conditions could only be recognized by its presence.

More precise statements were made by him in his monograph of 1909, or after the work of Thiemich and Mann, and von Pirquet. These will be considered later.

Escherich's earlier conclusions are sufficiently broad in their nature to admit of acceptance. Cathodal closing tetanus of anything more than the most momentary duration has not been found, in my study, in normal children under 5 years of age. The statement that electrical hyperexcitability is the most constant phenomenon in tetany of infancy has been generally accepted.[31] The question is, what values exactly indicate the presence of abnormal hyperexcitability, that is, what figures indicate overstepping the limits of normal variation?

Thiemich and Mann, at the conclusion of their studies, declared that in cases of tetany the values for cathodal closing contractions are lower than in normal infants, that there is an almost uniform occurrence of anodal opening values less than anodal closing values (A. O. C. < A. C. C.), and that cathodal opening contractions (C. O. C.) appear under 5 ma. (Thiemich's phenomenon). This last phenomenon they considered characteristic of tetany.

31. This is not to imply that electrical excitability (electrical values) may not rarely be perfectly normal in cases of clinical tetany at the time of making any single observation (see page 18).

In considering Thiemich's views it is well to examine the actual figures given by him.[32]

Thiemich and Mann's figures (averages) for cases of tetany are as follows:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
Tetany	0.63	1.14	0.55	1.94
Latent Tetany.....	0.73	1.45	0.95	2.93[33]

Their averages for normal children under eight weeks of age are as follows:

C. C. C.	A. C. C.	A. O. C.	C. O. C.
2.61	2.92	5.12	9.28

Children over eight weeks of age:

C. C. C.	A. C. C.	A. O. C.	C. O. C.
1.41	2.24	3.63	8.22

It has been thought by some later workers that certain children who suffered from less marked and unrecognized tetany must have been included in Thiemich's series of normal children, with consequent reduction of the averages. This seems evident from my figures for normal children, in comparison with which it appears that Thiemich and Mann's figures for normal children under eight weeks of age represent better the lowest figures found in normal children one year of age, and the average figures given by them for normal children over eight weeks of age are nearly as low as the lowest figures that I have found in normal children under a year of age, and lower than my average figures under five years. Not only are the figures given by Thiemich and Mann for normal averages too low, but the most infrequent occurrence of A. O. C. < A. C. C. (30 per cent. in the third year) is not indicated.

The lowest values tabulated by me for normal children under three years of age are as follows:

C. C. C.	A. C. C.	A. O. C.	C. O. C.
1.20	2.80	2.50	> 5

The average values are much higher:

C. C. C.	A. C. C.	A. O. C.	C. O. C.
2.50	4.20	4.30	> 5

There is thus seen to be a wide difference between Thiemich's averages for active and for latent tetany and the lowest figures founded by me in normal children.

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32. Due allowance should be made for the fact that Thiemich and Mann utilized the median nerve in their study. Later investigators have used the peroneal nerve (see page 6).

33. The figures for the two conditions are so nearly alike that they may practically be regarded as the same.

Though it is true that most cases of active, clinical tetany give findings that are much below the normal, and thus resemble Thiemich's findings more or less closely, yet there are other cases occasionally met with of undoubted clinical tetany which at no time in their course give findings as low as those of Thiemich and Mann for active and latent tetany.

If Thiemich and Mann's figures are made criteria of the presence of tetany, few erroneous diagnoses of tetany will be made, but many less-marked examples of clinical tetany will escape diagnosis, and most instances of latent tetany in which the electrical phenomena alone are present will pass unrecognized.

Von Pirquet stated his results very definitely and offered the conclusions given on page 7. He confined his study to infants, or children under two years of age. He divided them into three classes: (1) the normal; (2) those with latent tetany, and (3) those with manifest tetany. Those of the first class present only closing contractions under 5 ma.; those of the second class present anodal opening contractions under 5 ma.; while those of the third class (clinical tetany) give, in addition, cathodal opening contractions, or cathodal closing tetanus, under 5 ma.

Von Pirquet's conclusions are open to criticism. Anodal opening contractions under 5 ma. are frequently met with in infants under one year of age, and more frequently in children between one and two years of age. Anodal opening contractions under 5 ma. and under the value for the anodal closing contraction in the same patient, an even stricter definition of anodal hyperexcitability than is von Pirquet's, occur among normal children[34] with a frequency that increases progressively with the ages of the children until, in older children and in adults, it is a very common, if not regular, finding.

The phenomenon is met with in a considerable percentage of apparently normal infants under a year of age—probably about 10 per cent. It is not permissible, without further evidence, to say that such infants have latent tetany. They may show merely the early appearance of a phenomenon that is encountered with increasing frequency as age increases. The change is apparently one that accompanies normal growth, and one that finds several analogies, as, for example, the appearance of plantar flexion in response to plantar stimulation, a phenomenon seldom found in infants, more frequently met about the third year, and normally present in older children and adults.

Diagnostic significance would appear to be attached to the appearance of anodal hyperexcitability in infants, in children in whom it had not previously existed, or in connection with other suspicious condi-

34. See page 10 and Table 1.

tions. Its presence then becomes of diagnostic significance, and this significance is the greater the younger the child.

Escherich's later conclusions in his monograph, in 1909, were that there was as yet no general agreement as to the normal electrical values; that the values of von Pirquet were to be considered normal for the first year and indeed longer, though no exact studies for the later years of childhood had been made. Escherich accepted von Pirquet's three types of galvanic response in infancy, but questioned whether the milder grades of hyperirritability (von Pirquet's table) always indicate latent tetany.[35]

With the publication of the tables in the first part of this paper, there are now available tables showing the electrical values found in normal children, tables that show both the average values and the extremes between which lie the actual values from which the average values are computed. The figures show that normal children present various degrees of galvanic electrical irritability. There is a wide normal variation that must be taken into account. The interpretation of electrical reactions must vary with the age of the subject examined. At no age is it possible to draw a sharp line between normal and abnormal reactions.

Certain broad statements, however, may be made for use in clinical work:

Electrical hypersensitiveness is the most common and constant phenomenon in tetany of infancy and childhood.

Whether tetany may exist without essential change in the electrical reactions of an infant or child cannot be dwelt upon here. Frankl-Hochwart and Chvostek are said to have noted such occurrences in the adult. Thiemich suggested such a possibility for the child. All the other phenomena of tetany have frequently been reported absent in individual cases of tetany. And we may ask, why not the electrical phenomena? Certainly, in their more marked grades they may be absent at the time of any given observation.[36] The essential relation between electrical hyperexcitability and the clinical manifestations of tetany cannot be said to be known. Nor can the cause of the frequent and sometimes daily variations (Case 8) in electrical hyperexcitability during the course of tetany be said to be known.

Cathodal opening contractions and cathodal opening tetanus, of anything more than momentary duration, with a current of less than 5 ma., do not occur among normal children under 5 years of age. If certain organic diseases, such as hydrocephalus, spastic paraplegia, and cerebral sclerosis can be excluded, the presence of C. O. C. $<$ 5 ma. in

35. Escherich found a slight increase in electrical irritability in rachitis and organic nervous diseases, and Thiemich in microcephalus and cerebral sclerosis; in these cases the cathodal opening value lay above 5 ma.

36. See Case 8, January 5; Case 9; and Case 12, December 2 and 5.

children under 5 years indicates tetany. In children over 5 years, such is not necessarily the case.

The following cases show the value of C. O. C., and C. C. Te., < 5 ma. in diagnosis. One or two cases are also included to show that perfectly typical tetany may be present with the C. O. C. always greater than 5 ma.

CASE 1.—D. G., white girl, aged 8 months,[37] born in difficult, noninstrumental labor, was breast fed for three months, then given condensed milk mixture; during the last three weeks she was given cow's milk mixture, one half dilution. The child was born "blue" and remained so more than twenty-four hours. Jaundice appeared at birth and lasted six weeks. At the age of 5 months attacks "of getting blue and thumping of the heart" appeared. These came on without coughing, lasted five to ten minutes, and occurred three or four times a day at intervals of two or three days for one month. During the last two months the attacks were ushered in by sudden shortness of breath. First convulsion appeared eleven days before admission and lasted five minutes. The body became stiff, hands clenched and arms flexed; the tongue was bitten. Three similar attacks followed in the next three days, but were less severe.

The child was well developed and well nourished. There was slight epiphyseal enlargement. The spleen was not palpable. There was an inspiratory stridor. The thumbs were flexed on the palms, and there was a tendency to plantar flexion. The Trousseau phenomenon was present. The neck was rather short and thick. Roentgenography showed an enlargement of the heart and a probably enlarged thymus.

The child remained in the hospital twenty days and had no further convulsions until the last day. Her weight increased for ten days, then fluctuated, and during the last three days fell rapidly. The temperature at this time rose steadily from normal to 103.5. In the early morning the child was found hiccoughing, cyanotic, and making convulsive movements of the tongue and facial muscles, with the respirations irregular. There was no obstruction to the passage of air. Chloroform inhalations relieved the convulsions. The abdomen was much distended. The rapid heart sounds became weaker and weaker, and the cyanosis increased until death occurred.

Electrical examinations in Case 1:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.		
Feb. 13.....	0.3	2.9	1.2	3.1	Ch. 1[38]	Trousseau +
Feb. 15.....	0.9	1.9	1.4	3.9	Ch. 1	Trousseau +
Feb. 16.....	0.5	1.2	0.9	1.5	Ch. 1	
Feb. 17.....	0.7	2.6	1.2	3.8	Ch. 3	
Feb. 18.....	1.5	2.9	1.5	3.0	Ch. 3	
Feb. 20.....	0.9	2.7	1.3	3.2	Ch. 3	
Feb. 24.....	0.9	1.9	1.0	2.8		
Feb. 28.....	0.9	3.2	1.2	2.7	Ch. 2	
Mar. 3.....	1.4	3.5	1.8	4.8	Ch. 2	

A diagnosis was made of tetany, status lymphaticus, rachitis. The necropsy report showed general lymphatic hyperplasia, slightly enlarged thymus, cardiac hypertrophy and dilatation and a beginning bronchopneumonia.

This was a typical case of tetany. Even during the periods of freedom from attack there could be no question concerning the electrical values. They were much lower than the lowest values found in nor-

37. The age is always that at the time of making the first electrical examination.
38. Abbreviation for Chvostek, Grade 1, etc., see Footnote 28.

mal children of this age, and there was cathodal and anodal hyperirritability, as well as the presence of the Trousseau and Chvostek phenomena.

CASE 2.—L. D. J., girl, age 8 months, of normal birth, was breast fed. During the first days of the patient's life the mother noticed that the child twitched and shook in her crib, and breathed noisily and with difficulty. Convulsions became more frequent and severe after the sixth month, and when received the patient was having from five to eight daily. During attacks, the child "got stiff," "worked" in the crib, twitched, breathed with difficulty, became dark around the mouth and eyes, and the anterior fontanel bulged. Attacks were said to last a half hour, after which the child fell asleep. The child was well nourished. The Chvostek phenomenon was negative, and no signs of rickets were present. The diagnosis was epilepsy.

Electrical examinations in Case 2:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
Mar. 26	3.2	4.4	3.7	> 5.0
May 2	3.6	5.0	4.4	> 5.0
June 25	4.0	> 5.0	> 5.0	> 5.0

This case stands in sharp contrast to Case 1. It seems clearly a case of epilepsy. The values obtained, while below the average for this age, are not lower than those frequently found in apparently normal children. All clinical signs of tetany were absent.

CASE 3.—G. W., colored boy, aged 20 months, of normal birth, was breast fed for fourteen months, with table food in addition. Five or six weeks before admission to the hospital, the child was croupy and had attacks of spasms. Croupy cough reappeared a week before admission, accompanied by spasms in which the child lost his breath and grew stiff for two minutes. These attacks occurred from twelve to fifteen times daily, more commonly at night, and were accompanied by carpopedal spasm.

The child was well developed and moderately well nourished. There was enlargement of the costochondral junctions and of the epiphyses. The spleen was not palpable. On the second day after admission the child had three general and severe convulsions, with several minor convulsions following during the night. Dyspneas developed, and laryngeal examination showed the epiglottis and cords greatly swollen and edematous. The child became cyanotic, but an intubation tube could not be passed, and tracheotomy was performed, with immediate relief. After tracheotomy the patient's temperature rose and remained elevated. Death followed an attack of dyspnea and cyanosis on the eighth day.

Electrical examinations in Case 3:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.	
March 19	0.9	2.1	2.0	3.5	Ch. 2

This case is one of severe tetany. The history is distinctive; the presence of a Chvostek phenomenon at this age almost always indicates tetany; and the electrical findings, especially C. O. C. < 5 ma., are conclusive.

CASE 4.—W. B., boy, white, aged 20 months, with past history not obtainable from the foster parents, five days before admission to the hospital was found "throwing himself about" and was cyanosed. He soon became stiff. The attack lasted in all about five minutes. Two similar attacks followed on succeeding days. They were preceded by a crowing sound, and always appeared when the

child was irritated. He seemed to bring them on by holding his breath. His thumbs were turned into his palms much of the time. He was a stout child with a short, thick neck. The superficial lymph glands were somewhat enlarged, and the tonsils were large. The spleen was palpable. The morning after admission, the child suddenly became cyanotic and dyspneic. This attack passed off, but a convulsion followed shortly with dyspnea, cyanosis and death, artificial respiration being unavailing.

Electrical examinations in Case 4:

C. C. C.	A. C. C.	A. O. C.	C. O. C.	
1.4	2.4	1.6	2.9	Ch. 3

The clinical diagnosis was tetany and status lymphaticus, with an anatomical diagnosis of status thymicolymphaticus, lymphoid hyperplasia, beginning rickets.

CASE 5.—A. L. S., girl, white, aged 7 years, breast fed until 9 months old, said to have had whooping cough at 4 years, moderately severe attack of measles six months before admission, and three attacks of tonsillitis in past, had always been well otherwise and had never had convulsions.

Following tonsillectomy under ether at 10 a. m., on September 26, the child complained of severe cramps in the feet and legs at 4 a. m., September 27. At this time her hands and feet were in the characteristic tetany position. Trousseau and Chvostek phenomena were present. As the result of sedatives and a hot bath, the child slept the greater part of the day, and in the late afternoon the cramps in the hands and feet had passed away, though the Trousseau and Chvostek phenomena remained present. Recovery was uncomplicated. There was no sign of rachitis.

Electrical examination in Case 5:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.	
September 27, p. m.....	0.8	2.6	1.8	3.3	Ch. 3

Remarks: This child had been under the observation of Dr. Howland for six years. At no time previous to the above attack had she had any symptom suggestive of tetany. The attack came entirely unexpectedly, following a surgical operation. The child was seen in the following spring. At this time her reactions were as follows:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.	
March 21.....	1.3	2.8	2.3	>5.0	Ch. 2

She had no symptoms of tetany in the interim, and had been otherwise well.

The above case is an excellent example of clinical tetany following surgical manipulation of the neck in a 7-year-old girl. Its occurrence calls to mind all the theories of the Vienna school regarding the parathyroids and the supposed etiologic importance of disturbances of the blood supply due to prolonged assumption of unusual postures. The electrical values obtained, while typical of tetany at a younger age, were not lower than are found in some normal children of 7 years. Occurring in combination with undoubted clinical evidence of tetany, they scarcely admit of other interpretation.

CASE 6.—B. D., girl, colored, aged 2½ years, of normal birth, was breast fed for nine months, bottle fed for two months, then given table diet. After a normal infancy the patient suddenly developed carpopedal spasm (May 10), and on the same day had a convulsion, falling down, becoming stiff, and frothing at the mouth. On the night before admission to the hospital, June 5,

contractures of the hands and feet were present for one and a half hours, reappearing the next morning.

The patient was a well-developed and moderately well-nourished child. Rickets was marked. There was a persistent carpopedal spasm. A bloody nasal discharge, with thick, mucopurulent secretion in the posterior rhinopharynx, was present. Throat culture was negative for *Bacillus diphtheriae*. The contractures of the hands disappeared on the second day after admission, and those of the feet on the third day. The Chvostek phenomenon had disappeared by the thirteenth day.

When seen again in November, the Chvostek phenomenon was elicited with difficulty, and the electrical reactions were not abnormal, but approached the lower limits of normal values.

Electrical reactions in Case 6:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
June 5.....	0.4	2.0	0.6	> 5
June 5.....	0.3	4.0	1.8	> 5
June 5.....	0.4	3.0	1.8	> 5
Nov. 21.....	2.0	2.9	2.4	> 5
Dec. 3.....	1.8	5.0	2.3	> 5

This case of clinical tetany in an older child (2½ years) shows that C. O. C. < 5 ma. is not necessarily present during the height of manifest tetany, a fact noted by Ganghofner in 1904.

The following cases are included to show that electrical reactions identical with those in tetany may be met in cases of hydrocephalus and spastic paraplegia.

Case 7.—H. L., boy, white, aged 10 months, of normal birth, was breast fed for one month, then given proprietary foods and condensed milk and later cow's milk dilutions with sugar. At the age of 3 weeks the child suffered from a general convulsion, followed by stupor lasting for several hours. There had been no further convulsions, but at times the child had become rigid.

He was admitted to the hospital, April 18, as a poorly developed, poorly nourished infant, irritable, and somewhat spastic. The cranium was relatively enlarged and asymmetrical and the face small. There was fine nystagmus and a mild degree of choked disk. The reflexes were increased. The child was unable to sit alone and there was a rachitic rosary. The von Pirquet and Wassermann reactions were negative. There was little change in condition for one week; then there was rapid gain in weight (2 pounds, 12 ounces), and he was discharged May 28. He was treated thereafter in the outpatient department and did well.

Electrical examinations in Case 7:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.	C. C. Te.
April 25.....	0.9	3.2	1.9	....	4.0
May 22.....	3.1	> 5.0	4.1	> 5.0	
June	3.1	> 5.0	4.0	> 5.0	

In this case the Chvostek phenomenon was negative. A diagnosis of malnutrition and hydrocephalus was made. There was marked electrical excitability, without any other evidence of tetany, but with hydrocephalus.

Von Ranke[39] in 1894 noted the clinical resemblance to tetany[40] of early cases of hydrocephalus, with spasticity. The presence of cranial

39. Von Ranke: Zur Diagnose d. chronischen Hydrocephalus in dessen Anfangstadien bei noch nicht vorhandener Vergrosserung des Schädels, Wiener Naturforscher-Versammlung, Sept. 26, 1894, cited from Kalischer, Footnote 14.

40. See historical sketch, J. Cheyne, in early part of this paper.

enlargement, nystagmus and choked disk, and the absence of the usual clinical signs of tetany, are to be noted here.

Case 8.—B. C., girl, white, aged 3½ years, of normal birth, was breast fed for nine months, then weaned, and carefully fed thereafter. Slight convulsive movements had occurred before the child was 9 months of age, then numerous convulsions, until the time of admission. There had gradually developed paralysis on the right side, and eventually on the left side, with progressive mental and physical deterioration and spasticity of the extremities, but with no adductor spasm. There was slight Chvostek phenomenon.

After admission to the hospital, December 29, there were numerous clonic convulsions, sometimes ushered in by a cry, and there was marked rigidity. Rickets was not present. The von Pirquet was negative, Wassermann positive in both blood and spinal fluid. The child improved somewhat, and then declined, under vigorous antisyphilitic treatment. She was discharged unimproved.

Electrical examinations in Case 8:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.	C. C. Te.
Dec. 31 (right).....	1.9	1.9	2.0	> 5.0	
Dec. 31 (left).....	1.9	2.9	2.5	> 5.0	
Jan. 5.....	1.7	1.9	> 5.0	> 5.0	
Jan. 12.....	0.7	2.9	3.6	....	4.0 +
Jan. 21.....	3.1	> 5.0	> 5.0	> 5.0	
Jan. 24.....	2.0	4.0	> 5.0	> 5.0	
Jan. 29.....	1.9	2.9	1.0	> 5.0	
Feb. 9.....	2.2	3.0	> 5.0	> 5.0	
Feb. 18.....	1.5	1.9	1.7	....	4.0

This is an example of typical electrical reactions of tetany, appearing in a case of spastic paraplegia due to hereditary syphilis.

Anodal opening contractions appearing with a current less than that causing anodal closing contractions, and less than 5 ma., during the first six months of life are pathognomonic of tetany in almost all cases; their appearance with a current less than 2 ma. is probably pathognomonic of tetany up to the fourth or fifth year; thereafter their appearance alone is of little significance.

With anodal hyperexcitability we are undoubtedly dealing with a lower grade of excitability than with cathodal and with one which is rather indefinitely separated from the normal. This follows from the wide range of galvanic excitability found in normal children. The range of normal variation appears to become greater as children increase in age, and therefore the difficulty of determining abnormal degrees of excitability is increased in older children.

In practice the difficulty is not so great as it might seem. The majority of cases of clinical tetany present values that are evidently far below the normal (for example, Cases 1 and 4). Furthermore, the great majority of cases of true clinical tetany in childhood occur during infancy, the period when the difficulty of electrical diagnosis is slightest.

As a rule the electrical diagnosis of tetany can be readily made, provided the child be examined early enough and frequently enough. By

frequently enough is meant daily examination for a short period. Cases 9 to 12 serve to illustrate these points.

CASE 9.—A. M., boy, white, aged 5 months, of normal birth, was breast fed for two months and then given cow's milk and various infant foods. He was poorly nourished. There were no symptoms of tetany. He was admitted to the hospital September 27, and gained weight satisfactorily. He was treated in the outpatient department after December 5, and did well.

Electrical examinations in Case 9:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.	C. C. Te.
Oct. 22	4.8	>5.0	>5.0	>5.0	
Nov. 4	3.0	3.8	5.0	>5.0	
Jan. 26	2.7	>5.0	3.0	>5.0	
Jan. 29	1.5	2.4	1.9	....	4.3
Feb. 10	0.7	3.0	1.9	....	4.0+
Feb. 27	1.4	3.0	1.8	3.5	
Mar. 12	2.9	>5.0	3.0	>5.0	
April 6	4.5	>5.0	>5.0	>5.0	
May 18	3.1	>5.0	>5.0	>5.0	

The Chvostek phenomenon was doubtful, and there was no evidence of rickets found. The patient was an artificially fed infant in whom electrical hyperexcitability developed while under observation.

The case is to be regarded one of latent tetany in which recovery took place without developing symptoms of manifest, or clinical, tetany. The appearance of anodal hyperexcitability (January 26) in an infant of 7 months in whom this had not previously existed was the first evidence of the presence of heightened excitability of the nervous system. This was followed quickly (January 29) by cathodal hyperexcitability and the condition of increased excitability persisted for a month, and then disappeared without the development of any symptoms.

CASE 10.—R. B. A., boy, colored, aged 5 months, breast fed, with supplementary feedings later, was a healthy infant, well nourished, with no symptoms of tetany, but with beginning rickets.

Electrical examinations in Case 10:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
Oct. 25	2.0	5.8	3.0	>5.0
Nov. 6	2.0	3.8	2.7	>5.0
Nov. 18	2.2	>5.0	>5.0	>5.0
Dec. 3	2.2	>5.0	2.4	>5.0
Dec. 26 (right)	2.0	4.5	2.8	>5.0
Dec. 26 (left)	2.1	4.3	3.0	>5.0
Dec. 30 (right)	1.0	3.1	1.2	4.7
Dec. 30 (left)	1.2	2.5	1.4	4.8
Jan. 3	2.8	3.1	3.1	>5.0
Jan. 12	2.7	4.0	2.9	>5.0
Jan. 21	3.1	3.9	3.9	>5.0
Jan. 30	2.7	>5.0	3.5	>5.0
Feb. 7	2.1	>5.0	3.0	>5.0
Mar. 26	1.7	2.4	2.4	>5.0
May 15	1.7	3.0	3.0	>5.0

The Chvostek phenomenon was positive after the eighth month. The diagnosis of latent tetany is justified by the presence of anodal and cathodal hyperexcitability and a Chvostek phenomenon of moderate grade in a child with rickets.

Children suspected of tetany should be examined a number of times. Variations in electrical excitability are common during the course of the disease. In the above case the evidence of increased excitability was discovered during a routine examination (October 25), persisted for a time, and then disappeared entirely (November 18), only to return in more marked degree during the succeeding weeks.

CASE 11.—D. B., girl, colored, aged 18 months, of noninstrumental birth, but infant blue and respiration established with great difficulty, was breast fed for nine months, then given condensed milk and cereal. On January 10 the mother noticed that the child could no longer stand up when placed on her feet and that the feet and legs were swollen. There was fever. These symptoms continued until admission to the hospital. The child cried out in pain at times and drew her feet up. The swelling of the feet increased and the hands became clenched. Convulsive attacks appeared with increasing frequency.

She was a well-nourished child, with distinct evidences of rickets. There was slight bowing of the tibiae and lateral retraction of the chest wall. A condition of situs inversus of the viscera existed, but there was no general glandular enlargement. The spleen was just palpable. The Chvostek phenomenon was very marked, the very slightest touch producing marked contraction of the facial muscles. Typical carpopedal spasm existed. The child was admitted to the hospital February 2. The condition improved slowly, with no convulsions and no carpopedal spasm after February 5. Trousseau's sign was present until February 14. Chvostek phenomenon was less active after this date, but still marked.

Electrical examinations in Case 11:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
Feb. 2.....	1.2	3.0	1.8	7.5 (5.2)
Feb. 3.....	0.4	3.0	1.1	2.1
Feb. 5.....	0.8	2.2	1.6	4.0
Feb. 9.....	0.8	2.2	1.4	4.0
Feb. 13.....	1.5	2.0	2.0	3.0
Feb. 20.....	2.1	2.4	2.3	4.5
Feb. 18.....	1.8	3.0	3.5	5.0
Feb. 26.....	2.0	3.0	3.5	? (near 4.5)

The rapid appearance of cathodal opening values below 5 ma. is here interesting. It was preceded by marked symptoms and signs of tetany and by anodal hyperexcitability (February 2) which in this case was but little more marked than that found in a few apparently normal children (see Table 2). The appearance of cathodal hyperexcitability next day (February 3) was coincident with the cessation of convulsions.

CASE 12.—J. W., boy, colored, aged 11½ months, of full-term, noninstrumental birth, no cyanosis at birth, was breast fed for ten months, then given supplementary feedings of cow's milk. There was an indefinite history of convulsive attacks when the child was 9 days old, but otherwise he was apparently healthy. At four months he had whooping-cough with "nervous twitchings" of the hands. On the night of December 1 the child (then 11 months old) was feverish, restless and breathed very loudly, but there was no cough. Early next morning the child had a convulsion. In the afternoon the child had another convulsion, lasting three minutes.

He was a well-nourished child, temperature 102, throat slightly injected, with adenoids and a marked high-pitched inspiratory stridor. There were marked rachitic rosary and Harrison's grooves, and superficial glandular enlargement. The abdomen was slightly distended, spleen not palpable, reflexes difficult to obtain. No spasticity or paralysis was present. Chvostek and Trousseau phenomena were present.

Electrical examinations in Case 12:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.	
Dec. 2 (right) ...	2.4	4.5	3.5	>5	Ch. +
Dec. 2 (left)	2.8	4.8	3.8	>5	
Dec. 3 (right) ...	3.5	>5	>5	>5	
Dec. 3 (left)	3.7	>5	4.7	>5	Ch. 0
Dec. 4	...	...	...	...	Ch. +; Trousseau, suggestive
Dec. 5, 12 m.	3.4	>5	>5	>5	Ch. very faint
Dec. 5, 2 p. m....	2.4	>5	2.1	>5	
Dec. 7	2.0	3.5	2.2	>5	Ch. +; Trousseau +
Dec. 7 (later) ...	3.2	>5	3.1	>5	Ch. +

During the next four weeks there were no signs of tetany, with Chvostek doubtful:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
Jan. 14	>5	>5	>5	>5

There was striking daily variation of signs during the course of the tetany.

The case is of importance in showing the undoubted occurrence of normal electrical values during the course of tetany in infancy. The period of apparently normal electrical values was preceded by one of low electrical values, and followed by yet lower values. The presence at various times of all the other characteristic signs of tetany established the diagnosis. A single examination in this case, for instance, on December 3, might have led to an entirely erroneous diagnosis if the electrical examinations alone had been considered.

Tetany in Older Children.—By the term "older children" is here meant children of more than 3, and, more especially, of more than 5 years of age. In them the electrical diagnosis of tetany becomes difficult. The electrical standards of infancy certainly do not apply to older children. Formulas that in the infant would indicate the presence of tetany are common in healthy and apparently normal older children. Anodal hyperexcitability in its strictest definition becomes a frequent occurrence about the third year (40 per cent. in our series—see Table 1), and after the fifth year becomes the prevailing condition (67 per cent., in the fifth year, and 75 per cent. in the sixth year). Some children preserve the infantile formula as late as puberty, and physiologists differ as to which condition prevails in adult life. The occurrence of cathodal hyperexcitability (Thiemich's phenomenon) is not unusual in normal children over 5 years of age. The Chvostek phenomenon occurs frequently and in its lower grades (see Footnote 28) appears to be generally without significance.

The standards that have proved useful in infancy become less serviceable with increasing age. In children over 5 years of age it is necessary in making a diagnosis of tetany to adhere more closely to the criteria generally accepted for the diagnosis of tetany in adults.[41]

The electrical diagnosis of tetany, or even latent tetany, in older children by the standards of infancy rests on the most insecure foundation. Cases 13 and 14 will serve to illustrate the correctness of these statements.

CASE 13.—E. McK., boy, white, aged 8 years, of instrumental birth, was reared on diet poorly chosen, but not unusual. There were no symptoms of tetany. There was complaint of the presence of tapeworm. The child had never had convulsions, but there was a history of pertussis (1909), chicken-pox (1911), measles (1913), of an operation for abscess of neck (1910), and of otitis following measles. The present trouble began in 1911, and the child was treated with anthelmintics on two or more occasions. He was admitted to the hospital for three days, November 10. After treatment the patient passed seven feet of *Taenia saginata* segments. The Wassermann test, which was made because of suggestive family history and enlarged spleen and epitrochlear glands, was markedly positive. Antisyphilitic treatment was begun, and the child did well. He was readmitted to the hospital on January 28 because of the appearance of segments in the stools, and after treatment he passed six feet of worm.

Electrical examinations in Case 13:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
Nov. 10	0.3	1.4	1.2	2.4
Nov. 13	1.0	2.2	1.9	4.2
Jan. 28	0.25	2.1	1.9	4.8

The Chvostek phenomenon was not present at any time and no evidence of rickets was found.

This case is mentioned because of the extremely low electrical values found during the course of a routine examination. The patient was without suggestive history or symptoms. The reason for the occurrence of such low values in this child is not known. He was excluded from the series of normal reactions.

CASE 14.—A. R., girl, white, aged 9 years, with a mentally deficient Jewess as a mother, with a noninstrumental, but prolonged and difficult birth, was breast fed for eighteen months. The child is said to have suffered from "spasms" (abdominal cramps?) until 1 year old, but to have had none thereafter. She was brought to the outpatient department for treatment because of hyperesthesia and fleeting body pains that were occasionally sharp. She was poorly nourished and habitually constipated. The treatment from November 6 to February 14 consisted of tonics, better hygiene, half-time schooling, and correction of an error of refraction. The child improved steadily in appearance and her complaints became fewer, though there were occasional bad days.

On February 14 she was admitted to the hospital for closer observation, with complaint of pain in the right axilla, over the thorax, and around the heart. Examination showed normal temperature and pulse, carious teeth, palpable left thyroid lobe and exaggerated reflexes. The von Pirquet test was positive. The patient was discharged after five days, nothing further of importance having been found.

41. See standard texts, such as Oppenheim's Lehrbuch.

Electrical examinations in Case 14:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.	C. C. Te.
Nov. 6.....	<0.3	1.8	1.7	4.5	5.2
Nov. 8.....	0.6	2.1	1.5	3.2	3.5—4.5
Nov. 15.....	0.8	4.4	2.0	>5.0	
Nov. 20.....	0.9	3.0	1.9	4.4	
Dec. 2.....	1.1	4.2	2.0	>5.0	
Jan. 17.....	0.7	2.7	1.6	5.0—>5.0	
Feb. 18.....	1.0	2.9	2.1	4.7	

The Chvostek phenomenon was present, but not marked. Rachitis was not present. The diagnosis was neuropathic constitution.

It is not easy properly to classify this case. Many authors have enumerated such complaints as those described as symptoms of latent tetany, or, more commonly, of the so-called spasmophilic diathesis. At first glance it might be thought that electrical findings like the foregoing support such a hypothesis, but closer examination renders this at least doubtful. The electrical values found in this patient are low, but they are not lower than those found in many children of her age (see Tables 1 and 2—seventy children between 8 and 11 years of age). The Chvostek phenomenon, also, occurs not infrequently in children of this age (25 per cent.; see Table 1). Vague complaints like those enumerated are not uncommon among children of the patient's race and generally disappear with improved environment. They are proably not due to latent tetany.

Escherich's views regarding the electrical findings in puerile tetany may here be mentioned. He defined puerile tetany as tetany occurring in children over 3 years of age. His views may be summarized as follows:

The recognition of latent symptoms is determinative, their value with certain limitations, being the same as in infantile tetany. Presence of the Chvostek phenomenon, if in high grade (Grade 3), is probably pathognomonic, and the Trousseau phenomenon is unqualifiedly pathognomonic, if hysteria is excluded. Studies in the electrical values are lacking (1906) for this age, and the normal values have not been ascertained. It may be assumed, however, that the high values of infancy gradually approach the Stintzing values for adult life; and that the C. C. C. lies within from 1 to 1.5 ma., while the other values are higher. That outspoken electrical hyperexcitability will express itself in the C. C. C. sinking to 1 or less than 1 ma., the appearance of opening contractions under 5 ma., and the early appearance of tetanus, especially C. C. Te.

Some doubt was expressed whether the electrical signs alone will suffice for the diagnosis at this age of tetany and tetanoid conditions. Actual observations in cases of puerile tetany, as cited by him are as follows:

	C. C. C.	A. C. C.	A. O. C.	C. O. C.
At 7 years.....	0.4	0.8	0.6	0.8
	0.8	2.8	2.8	2.4
	0.1	1.4	1.4	<5
	1.0	2.0	1.0	<5
At 13 years.....	0.5	3.0	1.0	3.0

Also at 10 years C. C. Te. at 2.0 ma., and at 7 years A. O. Te. at 4 ma.

It is not felt that a diagnosis of tetany or latent tetany is warranted in either of the last two cases.

CONCLUSIONS TO CLINICAL PART

1. The appearance of cathodal opening contractions under 5 ma. (and in the absence of certain conditions already mentioned) in children under 5 years of age is pathognomonic of tetany. Cathodal opening contractions are, however, not infrequently absent in cases of clinical tetany.

2. The appearance of anodal opening contractions with less current than that causing anodal closing contractions, and under 5 ma. during the first 6 months of life is probably pathognomonic of tetany in all cases; their appearance with less current than that causing anodal closing contractions and under 2 ma. is probably pathognomonic up to the fourth or fifth year; thereafter it is of little significance.

3. The appearance of a Chvostek phenomenon under 2 years, in the absence of birth trauma, indicates tetany; under 4 or 5 years of age it is highly suggestive of tetany; its appearance in the highest grade (Grade 3, Escherich) is suggestive throughout childhood. After 3 years the Chvostek phenomenon is not infrequently found in milder grades in apparently normal children.

4. The occurrence of any one of these symptoms in association with a clinical history of tetany is to be considered conclusive evidence of tetany.

5. The determination of the electrical values is an extremely useful, but not always an infallible, means of diagnosticating active or latent tetany in childhood. It is most useful in infancy. Like other clinical tests, this one has definite limitations that must be recognized.

ELECTROCARDIOGRAPHIC STUDIES OF CONGENITAL HEART DISEASE*

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Congenital lesions of the heart may be divided into three groups, which are more or less independent of each other. These groups are anomalies of position of the heart, lesions of the structures controlling rhythm and conduction, and malformations of the chambers or orifices of the heart. The purpose of this paper is to report a group of cases in which the diagnosis of congenital heart disease has been made, presenting the electrocardiograms that have been obtained from them, and to offer an explanation for the form of electrocardiographic curve that has been associated with congenital heart disease. These cases have been under observation either in the St. Louis Children's Hospital or in the Washington University Dispensary during the past year. The electrocardiograms have been made at the Heart Station of the Department of Internal Medicine, under the direction of Dr. G. Canby Robinson.

Electrocardiograms that show a distinct difference from normal curves have been obtained by previous observers from cases of malformation of the heart, and it has been asserted that whenever electrocardiograms have been made from congenital malformations they have shown this variation from the normal. Such a point, if true, would be of great value in the diagnosis of malformations of the heart, especially if the curve is of a specific form, associated with no other condition. But before coming to such a conclusion it must be shown that such variations from the normal are constantly associated with lesions in a large number of cases, and it must be shown just what phenomenon in the heart is the cause of the abnormal form.

Einthoven[1] first called attention to an abnormal ventricular complex in congenital heart disease, but Steriopulo[2] first observed the form of curve that is usually associated with this condition. His curves were made from two cases and showed in Lead I, instead of the customary R wave of medium height and an S wave that is relatively small, a deep S wave and a very small R wave. He concludes that if these peculiari-

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1. Einthoven: Arch. f. d. ges. Physiol., 1908, cxxii, 517.
2. Steriopulo: Ztschr. f. exper. Path. u. Therap., 1910, vii, 467.

ties should show themselves to be characteristic in further examinations, then this method (electrocardiography) would play a great rôle in fixing the diagnosis of congenital heart disease. He also pointed out that great care must be exercised in the application of these findings, because it is not clear why this form of heart failure should show such unusual electrocardiograms. These observations were confirmed by Ratner,[3] who studied seventeen cases of congenital heart disease under the direction of Nicolai. From these studies Nicolai concludes that the deep S wave in Lead I is a characteristic sign of congenital malformation of the heart, and he states he had never seen a case of congenital malformation that failed to produce a curve of this type. Hecht[4] reports a series of nine cases, in two of which the S wave was absent in Lead I, and in one of these cases there was an unusually large Q wave. In the other seven cases the S wave was outspokenly prominent in one case, being much more so than the R wave. Einthoven[5] notes that in several cases showing tricuspid insufficiency, high-grade mitral stenoses or changes of position, a negative electrocardiogram was constantly associated with a hypertrophy of the right chamber. These conclusions were borne out by observations on a case showing defects of the interventricular septum and patent foramen ovale. Lewis[6] examined a series of twelve cases of congenital malformation of the heart in which cardiac enlargement, cyanosis and harsh systolic thrills and murmurs, maximal over the pulmonary cartilage, were the chief diagnostic signs. With two exceptions the electrocardiograms of these cases indicated generally extreme degrees of right-side hypertrophy. He further notes that curves showing signs of right-side hypertrophy with extreme amplitude of excursion are obtained only when there is reason to believe that congenital malformation is present; he says that exaggerated amplitude in several leads in itself is a valuable sign of congenital valve or septal defects.

In a paper such as this, it is not proposed to enter into a discussion concerning the influence that hypertrophy of the different chambers of the heart may have on the form of the electrocardiogram. Einthoven concluded from his studies that ventricular preponderance of one side of the heart or the other produces a very characteristic change in the electrocardiogram. The changes from the normal which he observed were that in right ventricular hypertrophy the S wave in Lead I is extraordinarily deep, and in Lead III the R wave is extraordinarily high. In left ventricular hypertrophy the R wave in Lead I is increased and in Lead III the S wave is increased. These observations

3. Ratner: Inaugural Dissert., Berlin, 1912.
4. Hecht: Ergebnisse d. inn. Med. u. Kinderh., 1913, xi, 340.
5. Einthoven: Zentralbl. f. Herz- u. Gefasskr., 1915, vii, 101.
6. Lewis: Clinical Electrocardiography, 1913.

have been further substantiated by other writers, notably by Lewis,[7] in many conditions that cause a hypertrophy of the chambers of the heart. It can be said that the relation between the height of the different waves of the electrocardiogram and hypertrophy of the heart is not a settled question, yet there are many observations that tend to confirm Einthoven's original conclusions.

Newborn infants and those during the first six months of life have been shown to give electrocardiograms with a deep S wave in Lead I. Hecht[4] and Lewis[6] have observed babies at intervals during the first year of life and have recorded a decrease in the size of the S wave in the electrocardiograms as the children grew older. In infants who fail to develop normally the infantile type of curve may persist longer than during the first year of life. In explanation of these curves it must is remembered that as a result of the activity of the heart during fetal life, the right ventricle shows a relative hypertrophy, which disappears as the circulation in the heart and the normal relations of right and left ventricular activity become established. These observations also bear out Einthoven's ideas concerning the relation between ventricular hypertrophy and the height of the waves in the electrocardiograms.

The following group of twelve cases of congenital malformation of the heart, from which electrocardiograms were obtained, are confirmatory of the relation between right ventricular preponderance and the type of curve mentioned by Einthoven, in which there is a small R wave and a deep S wave in Lead I and a large R wave and a small S wave in Lead III. They also show that this type of curve is not diagnostic of a congenital malformation, as has been supposed, and that all congenital malformations do not show this type of electrocardiogram. That is, if the congenital malformation is of such a nature that a right ventricular hypertrophy results, one will obtain this type of a curve. If the malformation is not associated with this secondary hypertrophy, this type of electrocardiogram fails.

CASE 1 (Children's Hospital No. 8253).—W. M., aged 23 months, was admitted to the hospital with diagnosis of congenital malformation of the heart, with defect of the auricular septum. The heart condition was first recognized on admission to the hospital March 31, 1915. There was no cyanosis. A rather diffuse faint thrill could be detected, best felt in the fourth interspace, 2 cm. to the left of the midsternal line. A very loud, rough systolic murmur all over chest was perceptible, best heard in the third left interspace. The heart dulness extended 3 cm. to the right and 7 cm. to the left of the midsternal line, a distinct enlargement in both directions. The liver was 2 cm. below the costal margin, and the spleen could just be felt. Roentgen-ray examination showed the heart greatly enlarged to the right and the left, with a body length of 59 cm. The patient's weight on admission was 3,000 gm., and during the subse-

7. Lewis: Heart, 1914, v, 367.

quent year there was a very slow gain, but with many fluctuations, to 3,600 gm. at death, Feb. 7, 1916. The red blood cell count was 4,672,000.

Electrocardiograms (275, Fig. 1) were made Dec. 10, 1915. They showed a rate of 131.6 per minute; conduction time Lead II, 0.121 second, with mechanism normal.

STRENGTH OF CURRENTS IN CASE 1

		Millivolts
Lead I	R wave	= 0.77
	S wave	= 1.35
Lead II	R wave	= 0.75
	S wave	= 0.82
Lead III	R wave	= 1.52
	S wave	= nil

Necropsy (No. 601) was performed by Professor Opie. His diagnosis was congenital anomaly of the heart, defect of auricular septum, chronic endocarditis of pulmonary, mitral and tricuspid valves (?). The necropsy findings are as follows:

The heart weighs 35 gm. The right auricle is of large size. The anterior surface of the heart is formed in large part by the right ventricle, which is considerably larger than the left. On exposing the auricles a wide circular foramen, 1 cm. in diameter, occupies the position of the foramen ovale and

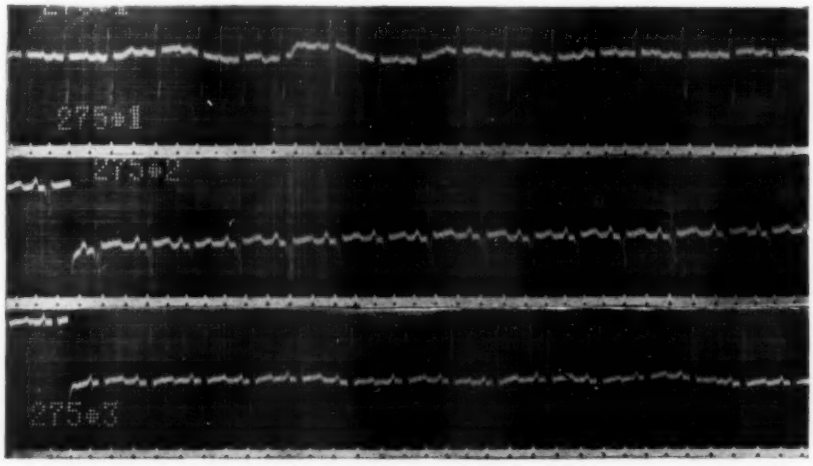

Fig. 1 (Case 1).—Defect of auricular septum; deep S wave in Lead I, high R wave in Lead III; right ventricular hypertrophy.

In this and the following illustrations the records were made directly on photographic paper. The tension of the string of the galvanometer was so adjusted that when 2 millivolts were thrown into the circuit, there was a deflection of the shadow of the string on the paper of 2 cm. Using this standardization, it has been possible to express the amplitude of the waves in terms of millivolts. In one instance (curve 350, Lead III, Fig. 8) the deflection was only 1 cm. for 2 millivolts. The time marker indicates fifths of a second. In measuring the amplitude of the waves and the conduction time at least ten heart cycles have been utilized in each estimation, the figures recorded being the average.

is wholly enclosed by a valvular fold. There is about the orifice a fairly narrow rim of tissue representing the interauricular septum. The right ventricle measures 3 mm. in thickness and is firm in consistency. The left ventricle measures 6 mm. The aortic valve is delicate and appears normal. Along the free edge of the mitral valve are translucent elevations which have the appearance of vegetations. There is a similar thickening along the free edge of the tricuspid valve. The free edges of the segments of the pulmonary valve are thickened and rounded; but otherwise there is no abnormality.

COMMENT

The clinical diagnosis presented no special difficulty, the only point being that it was not certain whether it was the auricular or ventricular septum that was patent, most of the evidence being in favor of the former. The electrocardiograms (Fig. 1) indicate a right ventricular hypertrophy. It was noticeable not only that there was a failure to gain weight normally on various foods, but also that there was no increase in body length and the child was backward in every other development. It is a very well known fact that congenital heart disease occasionally retards body growth and development very much and this patient is a striking example. It is probably of importance in this connection that there had not been any cyanosis.

CASE 2 (Children's Hospital No. 9738).—H. H., boy, aged 3 months, was received Jan. 20, 1916, with clinical diagnosis of congenital malformation of the heart, pulmonary stenosis (?), defect of interauricular or ventricular septum, and congenital syphilis.

Three weeks before admission there had occurred a spasm, during which the patient became blue. A much less severe spasm occurred ten days and a third four days previous to admission. These had been of very short duration, but the child had been blue each time and dark colored all the time. When the patient was seen in the hospital it was noted that there was irregular respirations suggesting Cheyne-Stokes type, associated at times with convulsive seizures of short duration, during which he became very cyanotic, especially about the face and head. At all times there was present a distinct duskiness of the skin, with definite cyanosis about the lips and buccal mucous membranes. There was slight clubbing of the finger tips. No thrills could be felt over the heart area. The point of maximum impulse was 2 cm. outside the nipple line. Dulness extended 1 cm. to the right and 6 cm. to the left of the midsternal line. There was a blowing systolic murmur, not very loud, heard at the apex, transmitted to the axilla and to the base of the heart. The murmur was faint but persisted. The second pulmonic tone was accentuated. The liver was 2 cm. below the costal margin. Roentgen-ray examination showed a broad heart shadow, with enlargement to the right and on the left, extending into the axilla. The Wassermann reaction was positive. Red blood cell count showed 3,968,000.

Electrocardiograms (332, Fig. 2) were made Jan. 21, 1916. They showed a rate of 126.4 per minute; conduction time Lead II, 0.121 second, with mechanism normal in Leads I and II. In Lead III the T wave was negative and there was considerable variation from the normal in the auricular complex, suggesting a diphasic action current.

STRENGTH OF CURRENTS IN CASE 2

		Millivolts
Lead I	R wave	= 1.52
	S wave	= 0.40
Lead II	R wave	= 2.25
	S wave	= 0.52
Lead III	R wave	= 0.80
	S wave	= nil

Necropsy (No. 596) was performed by Professor Opie. His diagnosis was congenital anomaly of the heart, fibroid atrophy of the right ventricle, hypertrophy and dilatation of the right auricle, patent foramen ovale, hypertrophy of the left ventricle. The necropsy findings are as follows:

The body length is 52.5 cm., weight 2,915 gm. The pericardium is of very great size, measuring 7.3 cm. transversely and 6 cm. from above downward. The pericardium contains a small excess of clear yellow fluid. The heart weighs 36.5 gm. When exposed, the right auricle is found to be of great size, forming only slightly less than one half of the anterior aspect of the heart. The right ventricle is of small size; the anterior surface of the left ventricle is about three times as great as that of the right. The right ventricle does not approach within 1 cm. of the apex. The left auricle is not distended. On section the cavity of the right auricle and auricular appendage is found greatly dilated. The muscle is hypertrophied so that the average thickness of the auricle is 2 mm. The right ventricle has a thin wall, about 1.5 mm. in thickness, containing very little muscle and abundant gray fibrous tissue. The pulmonary and tricuspid valves appear to be normal. The left auricle has an average thickness of 1 mm. The endocardium is gray. The foramen ovale is widely patent, having an orifice approximately 1 cm. in diameter. It is partly closed by a valve-like membrane, from the edge of which a fibrous cord passes to the wall of the left auricle. The aortic and mitral valves are normal. The left ventricle has an average thickness of 8 mm. The endocardium is gray and fibrous in appearance and there are gray markings in the muscle suggestive of fibrous tissue. The ductus arteriosus measures about 2 mm. in diameter. The lumen admits a probe about 0.5 mm. in diameter. The liver is very large, the spleen small.

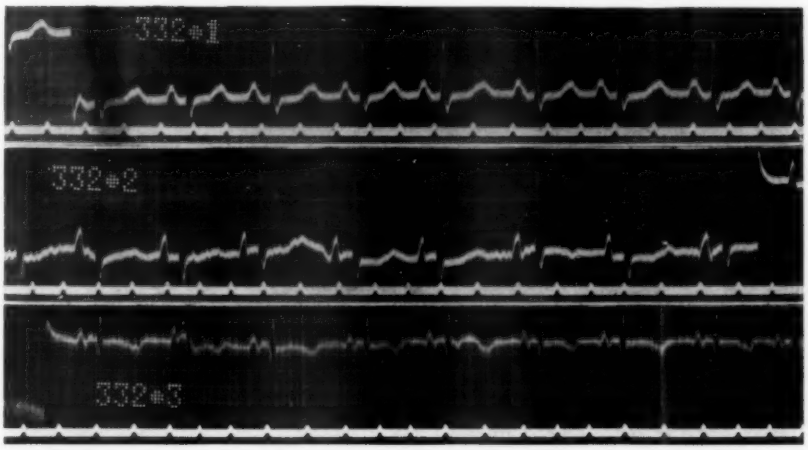

Fig. 2 (Case 2).—Patent foramen ovale; right ventricular atrophy; S wave in Lead I not increased.

COMMENT

The heart in this case was of a type of congenital malformation that is comparatively rare, there being only a few cases on record. The only other case from which electrocardiograms were made is mentioned by Einthoven,[5] but the publication of the electrocardiograms and notes on the heart has not yet

appeared. He mentions that the electrocardiograms were normal. In the case under discussion it will be noticed that the P wave (Fig. 2) is considerably larger than normal, indicative of the marked auricular hypertrophy found in the heart. This is in accordance with the view usually held that auricular hypertrophy is associated with increased amplitude of the P wave. Lead I suggests the left ventricular hypertrophy, but this is not borne out in Lead III, in which the S wave is entirely absent. The left ventricular hypertrophy found at necropsy is not very great, but, in proportion to the amount of muscle tissue in the right ventricle, evidence of left ventricular hypertrophy should be expected in the electrocardiogram. Lewis has suggested that evidence of right or left ventricular hypertrophy in the electrocardiograms depends not so much on the absolute as on the relative increase of the muscle tissue above the normal in one or the other chamber. What is more important in this case is that there is a congenital malformation of the heart in which the S wave in Lead I is not deepened, the point that has been insisted on as necessary for a diagnosis of congenital malformation of the heart. This exception apparently depends on the atrophy of the right ventricle that was found to exist at necropsy.

The patients in cases 3 to 12, inclusive, are still alive and continue to show signs suggesting more or less strongly a congenital malformation of the heart. The cases are reported in brief, for they further bear out the opinion that congenital malformations of the heart pro-

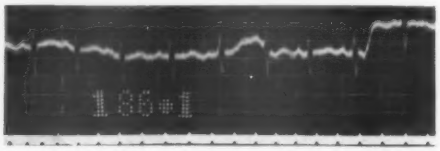

Fig. 3 (Case 3).—(Only Lead I obtained.) Pulmonary stenosis; right ventricular hypertrophy.

duce a deep S wave in Lead I of the electrocardiograms only when a right ventricular hypertrophy exists in consequence of the anomaly. It is fully realized that an attempt to diagnose a congenital heart malformation is uncertain at best and often erroneous. It is usually reasonably certain that a malformation exists, but the exact nature of such a lesion very often is open to discussion. It is especially true that two or more lesions are prone to occur in the same heart.

CASE 3 (Washington University Dispensary No. 16128).—L. D., boy, aged 10 months, was brought to the clinic for heart trouble. A diagnosis of congenital malformation of the heart and pulmonary stenosis was made. It was stated that the child had been a blue baby and subsequently had had repeated attacks, during which he became blue and the heart beat too fast and too hard. On examination there was noted cyanosis, mild clubbing of the fingers, a heart enlarged to the right, and there was a faint systolic murmur heard all over the precordium, best at the base.

Electrocardiograms (No. 186, Fig. 3) were made Oct. 12, 1915. They showed a rate of 158.8 per minute; conduction time Lead I, 0.118 second, with mechanism normal. Only Lead I was obtained.

STRENGTH OF CURRENTS IN CASE 3

		Millivolts
Lead I	R wave	= 0.38
	S wave	= 0.60

CASE 4 (Washington University Dispensary No. 16406).—M. W., aged 20 months, was received and a clinical diagnosis of congenital malformation of the heart and pulmonary stenosis was made. It was stated that at the age of 3 months it was noticed that the child became blue. There was a history of "jerking spells," the description of which resembled petit mal. Examination showed distinct cyanosis of lips, face, toes, fingers and nails. The heart dulness extended 2 cm. to the right of the midsternal line. A rough systolic murmur could be heard, loudest over the cardiac base, also in the back and all over the precordium. Roentgen-ray examination showed the heart only slightly enlarged to the left, moderately so to the right.

Electrocardiograms (191, Fig. 4) were made Oct. 18, 1915, showing rate 141.5 per minute; conduction time Lead II, 0.123 second, with mechanism normal.

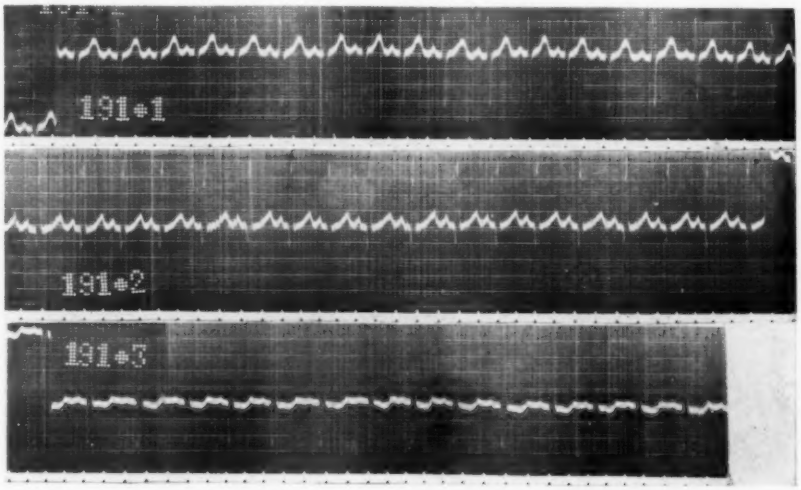

Fig. 4 (Case 4).—Pulmonary stenosis; right ventricular hypertrophy.

STRENGTH OF CURRENTS IN CASE 4

		Millivolts
Lead I	R wave	= 1.11
	S wave	= 1.50
Lead II	R wave	= 1.98
	S wave	= nil
Lead III	R wave	= 2.80+
	S wave	= nil

CASE 5 (Children's Hospital No. 9532).—F. B., boy, aged 10 years, was admitted to the hospital Dec. 3, 1915, with typhoid. A diagnosis of congenital malformation of the heart, pulmonary stenosis, defect of interauricular or ventricular septum. Blood culture and Widal reaction were positive. The boy had been a blue baby since birth, but had not had any convulsions. On exami-

nation he showed a marked cyanosis of all mucous membranes and skin. There was high-grade clubbing of all fingers and toes. The heart dulness extended 8 cm. to the left and 2.5 cm. to the right of the midsternal line. Over the entire precordium, best at the base, was heard a long, harsh systolic murmur, which was transmitted to the axilla, very faintly to the back, but not heard in the vessels of the neck. A very faint thrill could be felt over the pulmonic area. The liver was 2 cm. below the costal margin. The spleen could not be felt except during the first stages of the typhoid. The optic disks were moderately congested, and the retinal arteries were full and wavy, with the veins engorged, dusky blue and tortuous. No signs of atrophy in the disk or retina could be seen. Roentgen-ray examination showed a moderate enlargement of the heart both to the right and to the left. The red blood cell count was 6,200,000, hemoglobin 120 per cent. (Sahli). He was discharged from the hospital Jan. 4, 1916, recovered from the typhoid, the heart condition being the same, having had no apparent influence on the course of the typhoid.

Electrocardiograms (265, 271 and 336, Fig. 5) were made Dec. 3, 1915, to Jan. 23, 1916. These showed a rate of 121.7 per minute; conduction time Lead II, 0.169 second, with mechanism normal except for a slight delay in conduction during the typhoid.

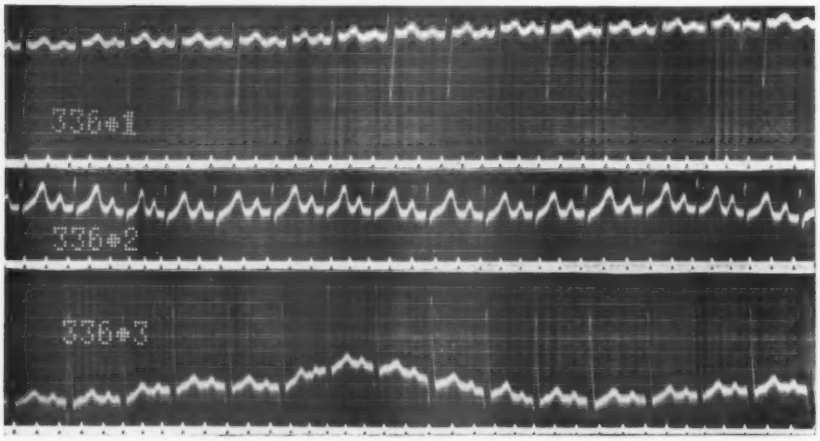

Fig. 5 (Case 5).—Pulmonary stenosis; right ventricular hypertrophy.

STRENGTH OF CURRENTS IN CASE 5

		Millivolts
Lead I	R wave	= 0.60
	S wave	= 2.10
Lead II	R wave	= 0.87
	S wave	= nil
Lead III	R wave	= 2.54
	S wave	= nil

CASE 6 (Children's Hospital No. 9535).—M. S., aged 9 years, was admitted to the hospital Dec. 4, 1915, for treatment for the heart condition. A diagnosis of congenital malformation of the heart, pulmonary stenosis and defect of the interauricular or ventricular septum was made. The child had been blue since birth, and with this condition was associated moderate dyspnea on exertion.

She also had fainting spells quite frequently. On examination she showed marked cyanosis of all mucous membranes and skin, and high-grade clubbing of all fingers and toes. There was a bulging of the precordium. A very faint thrill could be felt over the pulmonic area. The heart dulness extended 9.5 cm. to the left and 3 cm. to the right of the midsternal line. A long, rough systolic murmur could be heard everywhere, best over the base of the heart, transmitted to the axilla and distinctly heard in the left back. A very faint systolic murmur could be heard in the vessels of the neck. The liver was 2 cm. below the costal margin. The spleen could not be felt. The optic disks were markedly congested, the retinal arteries full, dark red and wavy and looked like veins. The veins were engorged, tortuous and dusky blue in color. No atrophy of disks or retina could be seen. Red blood cell count was 6,500,000, hemoglobin 115 per cent. (Sahli). Roentgen-ray examination showed a moderate enlargement of the heart shadow both to the right and left, especially the right.

Electrocardiograms (269 and 274, Fig. 6), made Jan. 4 and 10, 1915, showed a rate of 104.6 per minute; conduction time Lead II, 0.146 second, with mechanism normal.

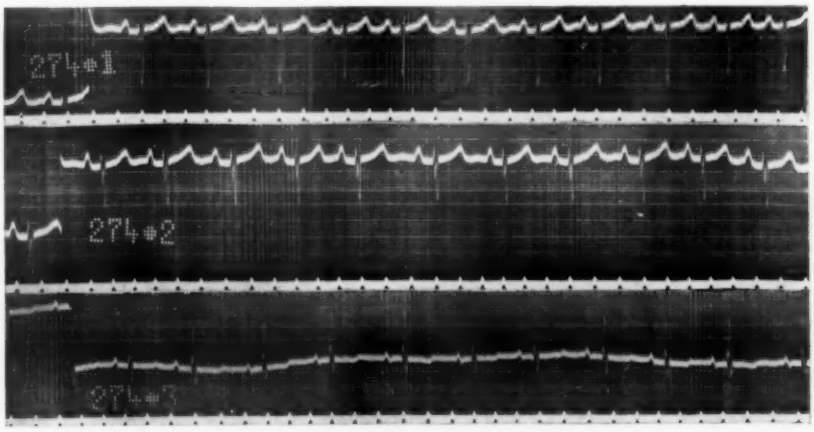

Fig. 6 (Case 6).—Pulmonary stenosis; right ventricular hypertrophy.

STRENGTH OF CURRENTS IN CASE 6

		Millivolts
Lead I	R wave	= 0.10
	S wave	= 1.46
Lead II	R wave	= 0.30
	S wave	= 1.20
Lead III	R wave	= 0.55
	S wave	= 0.20

CASE 7 (Washington University Dispensary No. 17548).—R. K., aged 8 years, was examined on entrance and a diagnosis of congenital malformation of the heart and defect of the auricular septum was made. There were no symptoms from the heart, and the condition was discovered during examination. There was no cyanosis or clubbing of fingers and no thrill over the heart. There was heard a loud systolic murmur all over the chest, best over the pulmonic area, but the expected enlargement to the right could not be made out on percussion.

Electrocardiograms (230, Fig. 7) were made Nov. 8, 1915, showing a rate of 97.1 per minute; conduction time Lead II, 0.174 second, with mechanism normal.

STRENGTH OF CURRENTS IN CASE 7

		Millivolts
Lead I	R wave	= 0.60
	S wave	= 0.60
Lead II	R wave	= 1.00
	S wave	= 0.60
Lead III	R wave	= 0.55
	S wave	= 0.20

CASE 8 (Children's Hospital No. 9805).—E. P., boy, aged 23 months, was admitted to the hospital Feb. 3, 1916, for heart trouble. A diagnosis of congenital malformation of the heart and defect of the interauricular or ventricular septum was made. The child was a blue baby at birth and has had numerous periods during which he became blue, but has had no convulsions. He did not show any cyanosis or lividity. No thrill was perceptible over the heart. Heart

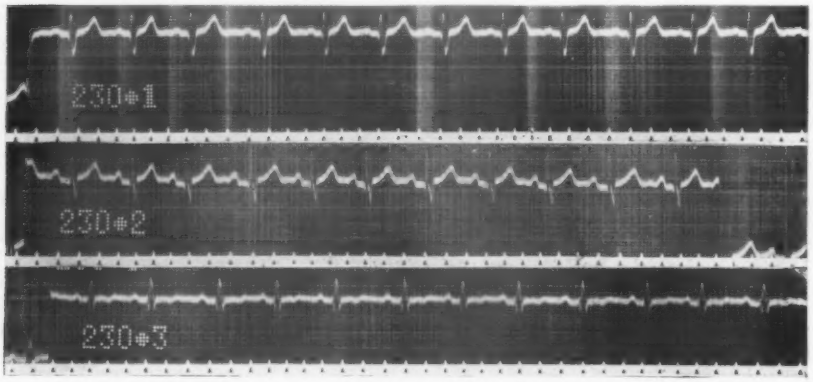

Fig. 7 (Case 7).—Defect of auricular septum; right ventricular hypertrophy.

dulness extended 1 cm. to the right and 5 cm. to the left of the midsternal line. There was a purring systolic murmur all over the heart area, most marked at the apex, transmitted to the axilla and back. The liver edge was at the costal margin. The red blood cells numbered 5,000,000. Roentgen-ray examination showed a heart enlarged markedly both to the right and to the left, and extending almost to the axilla.

Electrocardiograms (350, Fig. 8) were made Feb. 8, 1916, showing a heart rate of 75 per minute; conduction time Lead II, 0.188 second, with mechanism normal except for a slight delay in conduction. The curves suggest a left ventricular hypertrophy.

STRENGTH OF CURRENTS IN CASE 8

		Millivolts
Lead I	R wave	= 1.08
	S wave	= 0.49
Lead II	R wave	= 0.20
	S wave	= 0.20
Lead III	R wave	= 0.20
	S wave	= 1.00

CASE 9 (Washington University Dispensary No. 20878).—J. C., aged 7 months, was brought to the clinic with pneumonia. A diagnosis of congenital malformation of the heart and defect of interauricular or ventricular septum was made as a result of a general examination. No cyanosis could be seen, but the

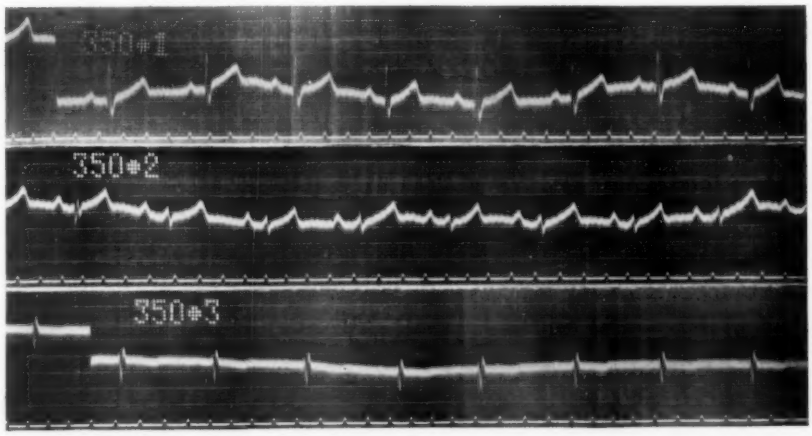

Fig. 8 (Case 8).—Defect of interauricular or ventricular septum; ventricular hypertrophy not evident in curves.

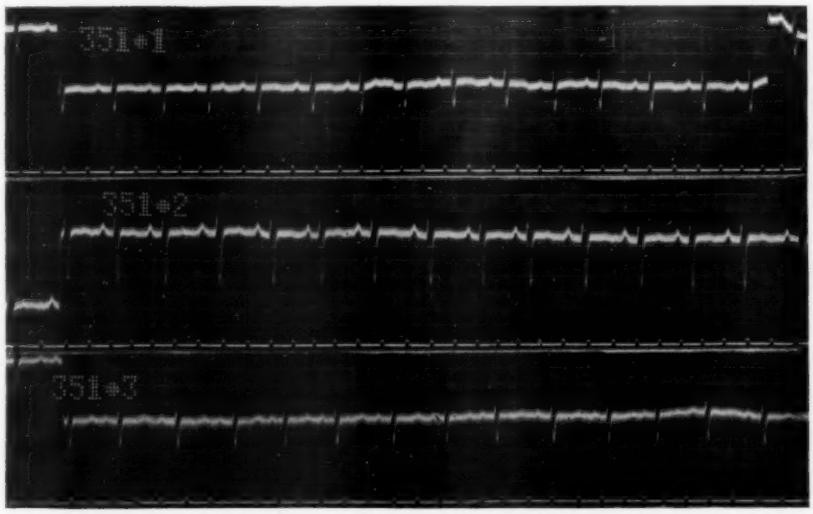

Fig. 9 (Case 9).—Defect of interauricular or ventricular septum; right ventricular hypertrophy (?).

skin at all times showed a marked lividity. No thrill could be felt over the heart. Dulness extended 2 cm. to the right and 5 cm. to the left of the midsternal line. A loud, rough systolic murmur could be heard all over the chest,

loudest to the left of the sternum about the third interspace. The liver was 4 cm. below the costal margin.

Electrocardiograms (351, Fig. 9) were made Feb. 10, 1916, showing heart rate 132.3 per minute; conduction time Lead II, 0.131 second, with mechanism normal.

STRENGTH OF CURRENTS IN CASE 9

		Millivolts
Lead I	R wave	= 0.35
	S wave	= 0.65
Lead II	R wave	= 0.42
	S wave	= 1.45
Lead III	R wave	= 0.20
	S wave	= 0.75

CASE 10 (Children's Hospital No. 9979).—L. McE., boy, aged 14 days, was admitted to the hospital March 12, 1916, when the heart condition was discovered and diagnosed as congenital malformation of the heart; consisting of a defect of the interauricular septum. Slight cyanosis was noticed the first

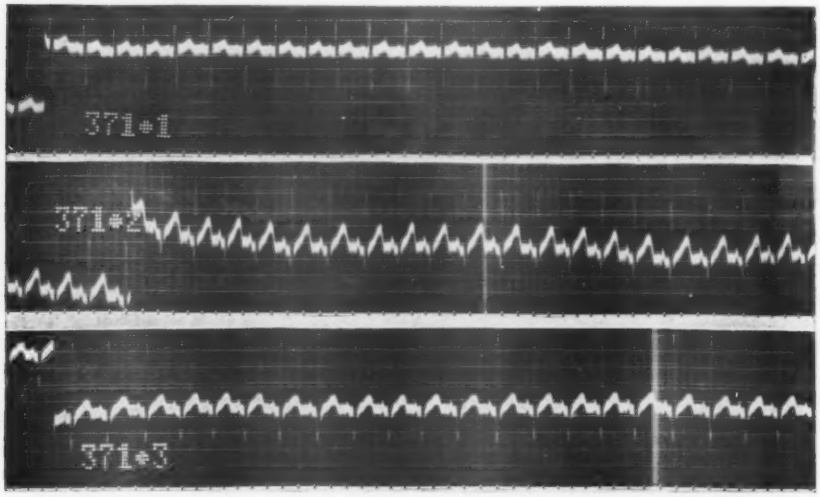

Fig. 10 (Case 10).—Defect of interauricular septum; right ventricular hypertrophy.

day of admission at several times, associated with shallow, slow respiration. But the cyanosis was not present constantly. No thrill could be felt. The heart dulness extended 2 cm. to the right and 5.5 cm. to the left of the midsternal line, a distinct increase, chiefly to the right side. A blowing systolic murmur could be heard all over the precordium, best at the base, not transmitted to the vessels of the neck or to the axilla. This murmur was rather indefinite at first, but before the patient's discharge, Feb. 23, 1916, it had become louder and more persistent. The red blood cell count was 3,232,000.

Electrocardiograms (371, Fig. 10) were made March 22, 1916, showing a heart rate of 132.3 per minute; conduction time, Lead II, 0.094 second, with mechanism normal.

STRENGTH OF CURRENTS IN CASE 10

		Millivolts
Lead I	R wave	= 0.80
	S wave	= 1.10
Lead II	R wave	= 1.74
	S wave	= nil
Lead III	R wave	= 2.26
	S wave	= nil

CASE 11 (Washington University Dispensary No. 19191).—L. F., aged 21 years, was admitted and a diagnosis of congenital malformation of the heart, patent ductus arteriosus, chronic cardiac valvular disease, and auricular fibrillation was made. The patient had had indefinite joint pains at the age of 15, and moderate to marked dyspnea for the past several years. No cyanosis or clubbing of fingers was shown. A systolic thrill could be felt most marked over the pulmonic area. The heart dulness extended 5 cm. to the right and 13 cm. to the left of the midsternal line, a marked enlargement in both directions. There was a rough systolic murmur heard over the pulmonic area and trans-

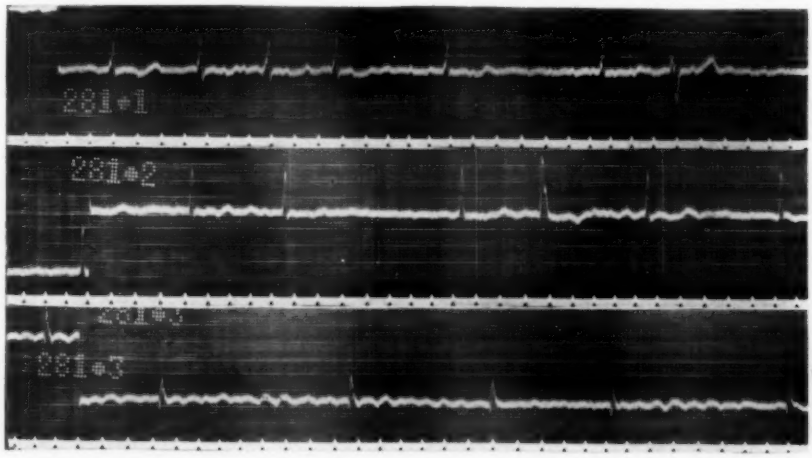

Fig. 11 (Case 11).—Patent ductus arteriosus; auricular fibrillation; right ventricular extrasystoles.

mitted down toward the apex, where a softer diastolic murmur could also be heard. At the apex a systolic murmur of a different pitch was perceptible, not transmitted very far into the axilla. In the axilla there was a rough diastolic murmur of different pitch and intensity. No murmurs were heard over the vessels of the neck. Fluoroscopic examination showed enlargement of the heart as made out by percussion. No auricular activity was seen.

Electrocardiograms (281, Fig. 11) was made Dec. 13, 1915, showing the heart rate to be 56.3 per minute, with coarse auricular fibrillation, ventricular extrasystoles, probably right sided.

STRENGTH OF CURRENTS IN CASE 11

		Millivolts
Lead I	R wave	= 0.91
	S wave	= 0.20
Lead II	R wave	= 1.35
	S wave	= nil
Lead III	R wave	= 0.67
	S wave	= nil

CASE 12 (Washington University Dispensary No. 17559).—W. H., woman, aged 32 years, was admitted and on general examination a diagnosis of congenital malformation of the heart, consisting of patent ductus arteriosus was made. There was no history of her ever having been blue. For the previous eight or nine years, she had suffered from dyspnea on exertion, and her lips became blue at such times. Examination showed a bulging of the chest to the left of the sternum. The point of maximum impulse of the heart could not be made out. Heart dulness extended 4 cm. to the right and 11 cm. to the left of the midsternal line. A broad area of retrosternal dulness at the level of the first and second interspace was made out. Otherwise heart dulness was not enlarged. A rather distinct murmur could be heard at the apex, faint in the aortic area and over the vessels in the neck. There was no clubbing of the fingers. Roentgen-ray examination showed marked enlargement of the upper heart shadow on both sides, especially to the left. The aortic curve was increased.

Electrocardiograms (159, Fig. 12) were made Nov. 12, 1915, showing heart rate 69.3 per minute; conduction time Lead II, 0.159 second, with mechanism normal.

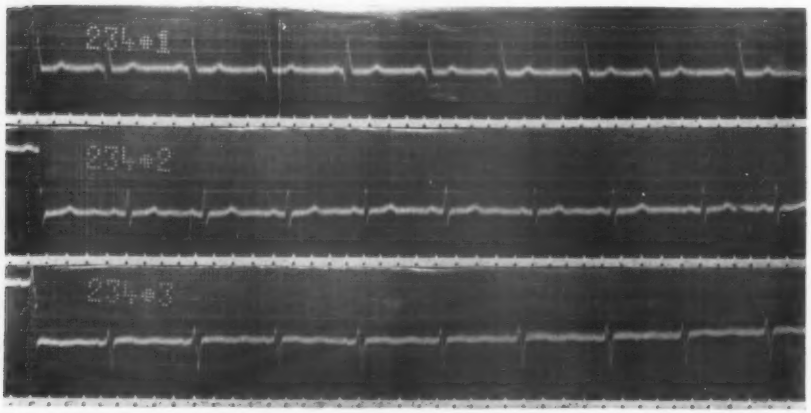

Fig. 12 (Case 12).—Patent ductus arteriosus; left ventricular hypertrophy.

STRENGTH OF CURRENTS IN CASE 12

		Millivolts
Lead I	R wave	= 0.90
	S wave	= nil
Lead II	R wave	= 0.70
	S wave	= 0.35
Lead III	R wave	= 0.35
	S wave	= 0.80

In Cases 3, 4, 5 and 7 a diagnosis of pulmonary stenosis was made, with or without septal defects. It is well known that stenosis of the pulmonary orifice produces a high-grade right ventricular hypertrophy, and looking at the electrocardiograms of these four cases, one sees in each strong evidence in favor of a right ventricular preponderance, there being no doubt about the deep S wave in Lead I and the high R wave in Lead III. Of all the curves in this report, these show the

right ventricular hypertrophy most clearly and distinctively. Two of these curves were made from children nine and ten years old, and so were completely removed from any influence that the period of infancy might have in producing this type of an electrocardiogram. The other two are from children in the second year of life. Only from a larger group of cases could the conclusion be drawn that this type of curve is associated constantly with a stenosis of the pulmonary orifice or that such a curve is diagnostic of pulmonary stenosis.

In Cases 7, 8, 9 and 10 the heart lesion is considered to be a defect of the septum, auricular or ventricular, or both. In each one the evidence of right-side enlargement made out by physical signs is lacking, or it can be shown that the enlargement involves both sides of the heart. Case 10 is that of an infant 14 days old and the illustration is confused by the normal effect that this period of life has on the electrocardiogram. Cases 7 and 9 show curves very different from the group of hearts with pulmonary stenosis, the curves in these cases being in fact very similar to those in Case 1 in regard to the size of the R and S waves in Leads I and III. This is in agreement with the anatomical fact that defects of the septums are very apt to produce an enlargement of both right and left ventricles. In all the electrocardiograms of the second group of cases the evidence of a predominating enlargement of the right chamber, such as is found in the first group, is not so strong. The relation of right ventricular hypertrophy to defects of the septum and the form of electrocardiogram may be seen by comparing this group of four cases with Case 2. In that case there was a free communication between the two auricles, and yet, due to the small amount of muscle tissue in the wall of the right ventricle, that chamber failed to undergo a secondary hypertrophy. It is hardly possible that the form of electrocardiogram produced by these four cases could be associated so constantly with septal defects as to make them pathognomonic.

Of the last two cases, Case 11 is confused by the presence of a valvular lesion and auricular fibrillation, and it would be impossible to say from the curves whether one side or the other is hypertrophied. And by physical signs and Roentgen-ray examination both sides are made out to be enlarged, chiefly the left. In Case 12 there is distinct evidence of a left ventricular hypertrophy.

CONCLUSIONS

Twelve cases showing congenital malformation of the heart are reported, including four cases of pulmonary stenosis, five cases of defects of the interauricular or interventricular septums, two cases of patent ductus arteriosus, and one case of right ventricular atrophy.

Congenital malformations of the heart do not produce a distinctive electrocardiogram, but the type of curve will depend on the secondary effects of the heart chambers. This effect is chiefly on the right side of the heart, and malformations associated with a secondary relative right ventricular hypertrophy produce electrocardiograms with deep S waves in Lead I and high R waves in Lead III. Malformations not producing right ventricular hypertrophy fail to cause a characteristic change in the electrocardiogram.

Electrocardiograms are of value in the study of congenital heart disease in that they throw additional light on the relations of the chambers of the hearts, and so may be of aid in determining the type of lesion present.

DIPHTHERIA IN THE FIRST YEAR OF LIFE*

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Though the occurrence of diphtheria in the first year of life was noted by Bretonneau,[1] who first gave the name to the disease, all authorities are agreed as to its rarity at this period. During the last fifteen years the percentage of diphtheria patients under one year admitted to the Metropolitan Asylums Board's Hospitals[2] has remained fairly constant, varying between 1.5 and 2.8 per cent. annually of the total cases admitted.

The figures given by some continental observers are slightly higher. Thus Flügge[3] states that among 6,394 cases of diphtheria in Breslau in the period 1886 to 1890, 160 patients, or 2.5 per cent., were under 1 year.

According to Filatow[4] the morbidity in southern Russia among children below 12 months was 4 per cent. of the total. In the Children's Hospital directed by Baginsky[5] in Berlin infants under 1 year formed 5.5 per cent. of the total number of diphtheria patients admitted; 1.4 per cent. occurring in the first six months and 4.3 per cent. in the second six months.

Several explanations of the rarity of diphtheria in the first year of life have been offered. It has been variousy attributed to immunity acquired in utero, to antitoxin transmitted through the mother's milk (Schmid and Pflanz[6]), to the acid reaction of the secretions in the buccal cavity of the infant, which is inimical to the growth of the bacilli (Monti[7]) and to the greater care and comparative isolation which the nursling as a rule enjoys (Jacobi[8]). Though decidedly more frequent in the artificially fed than in infants at the breast, diphtheria in the latter is by no means unknown. In addition to numerous isolated cases in the literature, epidemics of diphtheria in sucklings have been reported by Siredey[9] in 1877 at the Hôpital Larieboisière in Paris, and by Schlichter[10] in 1892 and Riether[11] in 1897 at foundling hospitals in

* Submitted for publication April 18, 1916.

1. Bretonneau: Memoirs on Diphtheria, New Sydenham Society, 1859.
2. Metropolitan Asylums Board Reports, 1888 to 1914.
3. Flügge: Ztschr. f. Hyg., 1894, xvii, 429.
4. Filatow: Quoted by Moltschanoff, Jahrb. f. Kinderh., 1907, lxv, 64.
5. Baginsky: Diphtherie und diphtheritische Croup, 1913.
6. Schmid and Pflanz: Wien. klin. Wchnschr., 1896, ix, 955.
7. Monti: Allg. Wien. med. Ztschr., 1896, xli, 1.
8. Jacobi: Twentieth Century Practice of Medicine, 1899, xvii, 78.
9. Siredey: Thèses de Paris, 1877, No. 337.
10. Schlichter: Arch. f. Kinderh., 1892, xiv, 129.
11. Riether: Wien. klin. Wchnschr., 1897, x, 666.

Vienna. Associated with the low morbidity is a high mortality. During the fifteen years, 1900 to 1914, the mortality among patients at this age in the Asylums Board Hospitals has ranged from a minimum of 14 per cent. in 1910 to a maximum of 41.4 in 1909, with an average of 32.1 per cent. as compared with a total mortality for all ages which has varied between 6.5 per cent. and 12.5 per cent. during the same period.

Though the mortality in the first year of life still remains regrettably high, it compares favorably with that in the preantitoxin era. Thus, the mortality in the Asylums Board's Hospitals in the period 1888 to 1893 was 69.9 per cent. for 146 patients under 1 year, and 31.3 per cent for 7,932 patients of all ages.

The mortality is always heaviest in the cases which require tracheotomy or intubation. In preantitoxin times recovery after surgical interference was quite exceptional at this age, as in the cases of Scoutteten,[12] who tracheotomized his own daughter, aged 6 weeks, and of Elias,[13] who successfully tracheotomized two children, aged 8½ months and 10 months, respectively. Of thirty-seven infants under 1 year who were tracheotomized at the Berlin University Surgical Clinic between January, 1884, and July, 1894, not one survived (Hirsch[14]).

Since the introduction of antitoxin the mortality rates both for tracheotomy and intubation are still high, though they show a considerable improvement over those of the preantitoxin era. Thus, among 129 infants under 1 year tracheotomized for diphtheria in the Asylums Board Hospitals between 1900 and 1909, the mortality was 69 per cent., and among nineteen intubated, 63.2 per cent. Among twenty-one infants of this age intubated at the Moscow Children's Hospital between 1895 and 1904, the mortality was 52.4 per cent. (Moltschanoff[15]).

Montefusco's[16] statistics are more satisfactory still. At the Ospedale Cotuguo at Naples between 1902 and 1907 there were only twenty deaths among forty-five infants intubated for diphtheria, a mortality of 44.4 per cent.

Several writers have drawn attention to the importance of congenital syphilis as a predisposing cause of diphtheria in the infant. Not only is the general resistance to infection weakened, but the nasal fossae, already the seat of rhinitis, serve as a *locus minoris resistentiae*.

12. Scoutteten: Ann. de méd. belges, 1844, ii, 58.
13. Elias: Deutsch. med. Wchnschr., 1878, iv, 555.
14. Hirsch: Arch. f. klin. Chir., 1895, xlix, 894.
15. Moltschanoff: Jahrb. f. Kinderh., 1907, lxv, 64.
16. Montefusco: La Pediatria, 1908, xvi, 82.

The present paper is based on a study of 2,600 consecutive cases of diphtheria that have been under my care at the Grove Hospital, London, in the course of the last twelve years. Of these, only twenty patients, or less than 1 per cent., were in the first year of life. Their exact ages were as follows:

5 weeks	1 case	7 months	2 cases
6 weeks	2 cases	8 months	3 cases
10 weeks	1 case	9 months	3 cases
11 weeks	1 case	10 months	1 case
5 months	2 cases	11 months	4 cases
Total	7	Total	13

Thus, nearly twice as many occurred during the second half as during the first six months of the year. Eight were males, twelve were females. The cases are classified in four groups, according as the throat, nose and larynx were attacked separately or in combination.

1. Purely faucial: very severe, 1; severe, 1; moderately severe, 1; moderate, 1; mild, 1; total, 5.

2. Purely nasal: severe, 1; moderate, 2; mild, 3; total, 6.

3. Purely laryngeal: moderate, 1.

4. Multiple lesions: very severe faucial and nasal, 1; severe faucial, nasal and cutaneous, 3; severe faucial and nasal, 1; severe faucial and nasal, mild laryngeal, 1; moderate faucial, nasal and laryngeal, 1; mild faucial, mild laryngeal, 1; total, 8.

Table 1 gives a brief summary of each case. Particularly remarkable is the high percentage of cases with nasal involvement. Whereas of the total 2,600 only 668, or 25.6 per cent., showed any localization of diphtheria in the nose, thirteen cases, or 65 per cent., of the infants under 1 year showed nasal diphtheria either alone or in association with other diphtheritic lesions elsewhere. On the other hand, the disease was by no means confined to the nose, even in some of the youngest infants, as an equal number of children showed some faucial membrane.

The unusual frequency of cutaneous diphtheria is also striking, namely, 15 per cent., as compared with 1.1 per cent. in the total 2,600 cases. In two cases the skin in the immediate neighborhood of the mouth or nostrils was affected, and in one, which I have discussed at length elsewhere,[17] the labium majus and skin around the anus. In only four was the larynx affected, in three of whom faucial membrane was also present. One required tracheotomy and died, the other three recovered.

In only three out of the twenty cases could the source of infection be detected. One girl, aged 5 months, with a moderate attack of nasal diphtheria of six days' duration, had probably been infected by her

17. Rolleston, J. D.: Lancet, London, 1910, ii, 947; Brit. Jour. Child. Dis., 1914, xi, 209.

TABLE 1.—Summary of Twenty Diphtheria Cases Giving Character of Attack, Treatment and Result

No.	Age, Mos.*	Sex	Character of Attack	Dose of Serum	Serum Phenomena	Complications	Result
1	5	♀	Severe nasal	4,000		Congenital syphilis, bronchopneumonia	Death
2	6	♀	Mild nasal	4,000	Circinate 4 days; erythema		Recovery
3	6	♀	Severe faucial, nasal and cutaneous	12,000 12,000 12,000		Palatal palsy, cardiac palsy	Death
4	10	♂	Mild nasal	4,000		Congenital syphilis	Death
5	11	♂	Moderate nasal	4,000			Recovery
6	5	♂	Moderate nasal	12,000	Urticaria 2 days		Recovery
7	5	♂	Mild faucial	4,000		Congenital syphilis	Death
8	7	♀	Mild nasal	1,000			Recovery
9	7	♀	Moderately severe faucial	12,000	Urticaria 5 days		Recovery
10	8	♀	Severe faucial, nasal and cutaneous	18,000			Recovery
11	8	♂	Severe faucial	15,000		Bronchopneumonia	Death
12	8	♀	Severe faucial Nasal and cutaneous	18,000 24,000		Palatal cardiac paralysis	Death
13	9	♀	Severe faucial Nasal and cutaneous	15,000 12,000	Urticaria 2 days	Otitis, bronchopneumonia	Death
14	9	♂	Moderate faucial Severe laryngeal	18,000 18,000		Tracheotomy, bronchopneumonia	Death
15	9	♀	Moderate faucial Severe faucial and nasal	12,000 12,000	Urticaria 2 days; cincinate erythema 9 days; no pyrexia		Recovery
16	10	♀	Mild laryngeal	12,000		Albumin	Recovery
17	11	♂	Severe faucial and nasal	18,000	Urticaria; abscess at injection site; cincinate erythema; joint pains; adenitis	Bronchopneumonia; relapse of diphtheria; scarlet fever	Recovery
18	11	♂	Moderate faucial Nasal and laryngeal	12,000 12,000		Albumin	Recovery
19	11	♀	Moderate laryngeal	8,000			Recovery
20	11	♀	Very severe faucial	18,000 18,000		Albuminuria; bronchopneumonia	Death

* The age of the first five patients is given in weeks.

sister, who had had a sore throat fourteen days previously and at the time of the patient's admission was said to speak "as if she had marbles in her mouth," that is, was probably suffering from paralysis of the palate. Another girl, aged 5 months, with mild nasal diphtheria of one day's duration, was admitted on the same day as her father, two brothers, and her mother, by whom she was being suckled, all of whom had a mild attack. The third patient, a girl aged 9 months, was admitted on the first day of a moderate faucial attack. Her sister, aged 9 years, had been admitted two days previously, with severe faucial diphtheria, on the sixth day of the disease, together with her brother, aged 3 years, in whom the attack was mild.

Three patients showed unmistakable clinical signs of congenital syphilis and it is highly probable that if the Wassermann test had been performed, latent syphilis would have been revealed in several more. In two cases death was due less to the attack of diphtheria, which in each case was mild, than to the concurrent syphilis.

None of the cases had immediately followed measles, which is often an antecedent of nasal diphtheria. With the exception of case 9, a moderately severe attack which made an uncomplicated recovery, the infection in all the breast-fed babies was confined to the nose. Not only is diphtheria itself uncommon during the first year of life, but its characteristic complication, paralysis, is also rare. Only two cases occurred among the twenty, each being examples of precocious palatal and cardiac palsy in very severe faucial diphtheria. The incidence of paralysis among the 2,600 patients of all ages was 19.8 per cent. On the other hand, bronchopneumonia, which was noted in only 1.2 per cent. of the patients of all ages, occurred in six of the twenty cases, or 30 per cent., five of which terminated fatally.

The high mortality in my twenty cases—nine deaths, or 45 per cent. —was thus mainly due to bronchopneumonia, which caused five deaths; cardiac paralysis, responsible for two deaths, and congenital syphilis for two.

Treatment.—In accordance with the practice prevalent in most of the Asylums Board Hospitals, the doses of serum given were relatively high. The patients with mild attacks received from 1,000 to 4,000 units, those with moderate attacks from 8,000 to 12,000, and those with severe attacks 12,000 to 24,000 units in a single injection, which was in some cases repeated. The highest total reached in any case was 42,000 units. With the exception of one patient, a boy of 11 months, who received 18,000 units for a severe faucial and nasal attack, and who developed, in addition to the ordinary urticaria, a circinate erythema, cervical adenitis, joint pains, and an abscess at the injection site, no serum manifestations of any severity were observed. As I have shown elsewhere the intramuscular method may be used in quite young children without any ill effects.

SUMMARY

1. Diphtheria in the first year of life is comparatively rare. Only twenty patients at this age occurred among a total of 2,600 diphtheria patients of all ages.

2. Congenital syphilis is an important predisposing cause.

3. Sixty-five per cent. showed some nasal involvement, with or without other diphtheritic lesions elsewhere, as compared with 25.6 per cent. in the total. Thirty per cent. were purely nasal, as compared with 1.5 per cent. of the total cases.

4. The mortality was high, 45 per cent., as compared with 7.3 per cent. in the total.

5. Paralysis was rare, two cases; bronchopneumonia, six cases, was common.

6. A history of infection was obtained in only three cases.

A METABOLISM STUDY OF A CASE OF DIABETES INSIPIDUS*

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INTRODUCTION

Diabetes insipidus may be divided into two types: (1) primary or idiopathic cases, including those cases in which there is no evident organic basis for the disease, and (2) symptomatic, including those cases in which some organic disease is present in the brain or elsewhere.

At the present time three theories as to the etiology of diabetes insipidus are held: (1) that it is due to a lack of ability of the kidneys to concentrate the urine; (2) that a primary polydipsia exists with normal kidney function; (3) that it is a polyuria, purely symptomatic in origin, produced by stimulation of the kidney by many causes, but in some cases by a hypersecretion of the hypophysis.

Erich Meyer[1] was the first to claim that the condition was due to a lack of ability of the kidney to secrete a concentrated urine. He showed that in normal individuals the ingestion of sodium chlorid was followed by a depression of the freezing point of the urine, indicating an increased molecular concentration, while in cases of diabetes insipidus the ingestion of sodium chlorid caused no depression of the freezing point, but an increase in the amount of urine excreted. Tallqvist,[2] Socin,[3] and others agree with Meyer. Finkelnburg,[4] Schwenkenbecher[5] and Forschbach and Weber,[6] from experimental evidence considered that in this condition the concentrating power of the kidney is not lost, but that the kidney is, under pathologic stimulation, excreting large amounts of urine. Schwenkenbecher also thinks that there exists an acquired tolerance for water on the part of the kidneys and rest of the

* Submitted for publication April 12, 1916.

* From the Biochemical Laboratory of the Western Pennsylvania Hospital.

1. Meyer, Erich: Deutsch. Arch f. klin. Med., 1905, lxxiii, 1; Deutsch. Klin, 1910, xiii, Supplement ii, 271; Ztschr. f. klin. Med., 1912, lxxiv, 352; Ueber den gegenwartigen Stand der Path. a. Ther. d. Diabetes insipidus, Halle, 1914.
2. Tallqvist: Ztschr. f. klin. Med., 1903, xlix, 181.
3. Socin: Ztschr. f. klin. Med., 1913, lxxviii, 294.
4. Finkelnburg: Deutsch. Arch. f. klin. Med., 1910, c, 33.
5. Schwenkenbecher: München. med. Wchnschr., 1909, lvi, 2564.
6. Forschbach and Weber: Ztschr. f. klin. Med., 1911, lxxxiii, 221; Ibid., 1913, lxxvii, 153; see also, Günther: Ztschr. f. klin. Med., 1914, lxxviii, 53, and Lichtwitz and Stromeyer: Deutsch. Arch. f. klin. Med., 1914, cxvi, Nos. 1 and 2.

body in this disease, somewhat like the acquired tolerance for drugs that some individuals possess.

Engel[7] considers that in diabetes insipidus there is present a prolonged nerve stimulation, possibly in the medulla, which excites the glomeruli to greater secretion or the tubules to diminished resorption or both. Stuber[8] thinks diabetes insipidus is a manifestation of adrenalinemia, due to an increased function of the chromaffin system. Ebstein[9] thought the condition was due to a primary polydipsia with a resultant polyuria.

Frank,[10] on the basis of much study, considered that many cases of essential diabetes insipidus were caused by a hyperactivity of the pituitary, with resulting diuresis, as it has been shown by Schäfer and Herring[11] and many others that the secretion of the pituitary has a strong diuretic effect.

Cushing's[12] studies also point out the importance of this gland in relation to diabetes insipidus. Goldzieher,[13] Berblinger[14] and Simmonds[15] have pointed out relations between diabetes insipidus and lesions in and about the pituitary, especially its posterior part. Roemer[16] reports experiments and clinical observations which tend to show that some cases of diabetes insipidus are due to a lack of secretion of the pars intermedia, and not to a hyperfunction of this gland.

Motzfeldt[17] has published a very able summary of the literature in regard to diabetes insipidus and the pituitary, and reports three cases of diabetes insipidus in which nothing abnormal was found in the pituitary, but a number of symptoms pointed to an insufficiency of the posterior lobe of the pituitary.

Kahlmeter[18] has also reviewed the literature regarding the relation between the pituitary and diabetes insipidus. Kleeblatt[19] has recently described an interesting case of diabetes insipidus that followed trauma

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7. Engel: Ztschr. f. klin. Med., 1909, lxvii, 112; Maly's Jahrb. f. Tierchem., 1907, 858.
8. Stuber: Deutsch. Arch. f. klin. Med., 1911, civ, 394.
9. Ebstein: Deutsch. Arch. f. klin. Med., 1909, xcv, 1.
10. Frank: Berl. klin. Wchnschr., 1912, xlix, 393.
11. Shäfer and Herring: Phil. T. Roy. Soc. London, Series B, 1906, cxcix, 1.
12. Cushing: The Pituitary Body and Its Disorders, 1910.
13. Goldzieher: Verhandl. d. deutsch. path. Gesellsch., 1913, xvi, 272.
14. Berblinger: Verhandl. d. deutsch. path. Gesellsch., 1913, xvi, 281.
15. Simmonds: München. med. Wchnschr., 1914, xl, 108.
16. Roemer: Deutsch. med. Wchnschr., 1914, xl, 108.
17. Motzfeldt: Norsk Mag. f. Lægevidensk., 1915, lxxvi, 1305; Barabo: Ueber Diabetes insipidus mit Infantilismus, Dissert., Munich, 1914; Dziembowski: Ueber den ursächlichen Zusant. zwischen Hypophysis cerebri u. Diabetes insipidus, Dissert., Breslau, 1914.
18. Kahlmeter: Hygiea, 1915, lxxvi, 1073.
19. Kleeblatt: Med. Klin., 1915, xi, No. 33.

of the skull. Camus and Roussy[20] have reported extensive experiments which seem to show that the pituitary is not responsible for diabetes insipidus. Fitz[21] has recently reported a very thoroughly studied case of diabetes insipidus in a boy of twelve and found that tests for renal function for the kidney as a whole were normal, but gave findings characteristic of vascular hyposthenuria, with vessels hypersensitive to chlorid stimulation. He found that the concentrating powers of the kidneys were not entirely lost.

CASE HISTORY

O. T., boy, aged 4 years, American, with one sister living and well, had no history of consanguinity, alcoholism, syphilis, tuberculosis or cancer. The patient had had no fall or injury, no childhood diseases. Labor was perfectly normal. About one year previously the patient had begun to void in bed. He drank water almost continually and voided about every twenty minutes. Except for these symptoms he appeared in perfect health.

The patient was well developed, of normal size and the color was good. There were no eruptions or adenopathies. The nose, mouth and pharynx, ears, eyes and cranial nerves were normal. The chest was small, round, symmetrical. No enlargement of the thymus could be made out. The lungs, heart, and abdomen were normal. His hands and feet were well formed. The genital organs were normal. No abnormalities were present in the nervous system. Temperature, pulse, and respiration were all normal.

The blood count showed erythrocytes, 3,800,000; hemoglobin, 68 per cent.; leukocytes, 7,000; polynuclears, 45 per cent.; small lymphocytes, 31 per cent.; large lymphocytes, 17 per cent.; eosinophils, 5 per cent.; basophils, 2 per cent.

The Wassermann reaction in the patient's blood and in that of his mother and father were negative. Roentgen-ray examination of the skull showed a normal sella turcica. The tuberculin and von Pirquet tests were negative.

EXPERIMENTAL

The plan of the experiment and the methods used for the estimation of the various substances in the food and excreta were the same as those described in previous papers.[22] The chlorid estimations were made by Volhard's method, and the freezing point of the urine was determined by Beckmann's method.

The tables contain the results obtained in this study. During the nine days of study the patient retained 4.08 gm. of nitrogen. The urea nitrogen, ammonia nitrogen, amino-acid nitrogen, creatinin, uric acid, purin nitrogen and undetermined nitrogen are normal in amount and in the percentage of the total urinary nitrogen. The urinary acidity is also normal.

Vannini[23] in one case found the urea nitrogen 86.1 per cent., in another 90.66 per cent. of the total urinary nitrogen. Butler and

20. Camus and Roussy: Presse méd., 1915, xlvi, 517.
21. Fitz: Arch. Int. Med., 1914, xiv, 706.
22. Rosenbloom: Am. Jour. Med. Sc., 1911, cxlii, 7; Ibid., 1913, cxlvi, 731; Ibid., 1914, cxlviii, 65; Arch. Int. Med., 1913, xii, 276; Ibid., 1914, xiv, 263.
23. Vannini: Berl. klin. Wchnschr., 1900, 638.

French[24] found it 94.96 per cent. Von Jaksch,[25] however, found very peculiar figures for the urea nitrogen in a case he studied. More than half the entire urinary nitrogen was excreted as amino-acid nitrogen, with a correspondingly low amount of urea nitrogen. The ammonia and uric acid figures have been found normal in previous studies.[26]

With an increase in the nitrogen intake on the sixth day of the metabolism study, it may be noted that there was a consequent increase in the amount of nitrogen excreted in the urine, showing that the kidneys were perfectly capable of excreting increased amounts of nitrogen.

TABLE 1.—THE NITROGEN METABOLISM—

Day	Volume, C.c.	Total Acidity in C.c. of N/10 NaOH to Neutralize 24 Hours' Urine, C.c.	Total Nitrogen, Gm.	Urea Nitrogen		Ammonia Nitrogen		Amino-Acid Nitrogen		Creatinin		
				Gm.	Per Cent. of Total Nitrogen	Gm.	Per Cent. of Total Nitrogen	Gm.	Per Cent. of Total Nitrogen	Gm.	Nitrogen, Gm.	Nitrogen in per Cent. of Total N
1	1,890	113.4	5.9	5.0	84.7	0.254	4.3	0.059	1.0	0.278	0.101	1.7
2	3,080	240.2	9.1	7.6	83.5	0.379	4.2	0.1092	1.2	0.384	0.140	1.5
3	3,080	209.4	7.6	6.3	82.9	0.345	4.5	0.1064	1.4	0.406	0.148	1.9
4	4,000	192.0	8.8	7.2	81.8	0.437	4.9	0.1320	1.5	0.432	0.157	1.8
5	5,190	207.6	8.4	7.0	86.9	0.436	5.2	0.0924	1.1	0.561	0.204	2.4
6	4,305	301.0	11.2	9.4	83.9	0.687	6.1	0.1904	1.7	0.697	0.254	2.3
7	4,400	176.0	8.9	7.4	84.3	0.567	6.4	0.1602	1.8	0.536	0.195	2.2
8	4,260	153.4	12.4	10.3	83.1	0.561	4.5	0.1860	1.5	0.511	0.186	1.5
9	5,500	154.0	11.1	9.2	82.9	0.478	4.3	0.1554	1.4	0.612	0.223	2.0

A very interesting finding is the low percentage of nitrogen in the stool as compared to the nitrogen ingested. It shows a very complete absorption of the nitrogen intake, no doubt due to the increased ingestion of water, which Hawk[27] and his co-workers have shown lessens the amount of fecal protein excreted.

There has been considerable controversy regarding the protein[28] metabolism in diabetes insipidus. Some report the loss of protein in

24. Butler and French: Guy's Hosp. Rep., 1904, lvii, 133.
25. Von Jaksch: Ztschr. f. klin. Med., xlvii, 46.
26. Vannini, Butler and French, and von Jaksch, Footnotes 23, 24 and 25.
27. Hawk and Fowler: Jour. Exper. Med., 1910, xii, 388; Mattill and Hawk: Jour. Am. Chem. Soc., 1911, xxxii, 1999.
28. Tallqvist, Footnote 2; Vannini, Footnote 23; Butler and French, Footnote 24; Strubell: Deutsch. Arch. f. klin. Med., 1899, lxxxix, 62; Hirschfeld: Fest. f. Salkowski, 1904, 187; Gerhardt: Nothnagel's Spec. Path. u. Ther., 1900, vii, 7; Ferranini: Jahresb. ü d. Leistung. in d. ges. Med., 1902 ii, 52.

this disease, in spite of a diet of sufficient caloric and nitrogen value. Others claim that the state of nutrition undergoes no important change which is also true of the protein metabolism. From our experiments in this case we would agree with this conclusion, as does also Gerhardt.[29]

When a normal individual on a standard diet containing a definite quantity of sodium chlorid receives in addition from 10 to 15 gm. of sodium chlorid, the sodium chlorid concentration in the urine increases, while the total volume of urine excreted varies slightly, if at all. In a patient with diabetes insipidus, however, increasing the sodium

—AND URINARY NITROGEN PARTITION

Uric Acid			Purin Nitrogen		Undetermined Nitrogen		Feces Nitrogen		Balance	
Gm.	Nitrogen, Gm.	Nitrogen in per Cent. of Total N	Gm.	Per Cent. of Total Nitrogen	Gm.	Per Cent. of Total Nitrogen	Gm.	Per Cent. of Nitrogen Intake	Nitrogen Intake, Gm.	Nitrogen Balance, Gm.
0.042	0.014	0.24	0.004	0.07	0.468	7.9	0.30	4.9	6.1	—0.10
0.048	0.016	0.17	0.0087	0.095	0.85	9.3	0.45	5.4	8.3	—1.25
0.048	0.016	0.21	0.0044	0.058	0.68	8.9	0.33	3.7	9.0	+1.07
0.039	0.013	0.15	0.0148	0.160	0.85	9.6	0.42	5.1	8.2	—1.02
0.061	0.027	0.32	0.0141	0.167	0.63	7.5	0.40	4.4	9.1	+0.30
0.060	0.020	0.18	0.023	0.20	0.63	5.6	0.53	4.3	12.2	+0.47
0.057	0.019	0.21	0.012	0.14	0.55	6.2	0.41	3.2	13.0	+3.69
0.060	0.020	0.16	0.014	0.11	1.13	9.1	0.51	3.9	12.8	—0.11
0.099	0.033	0.30	0.020	0.18	0.99	8.9	0.56	4.5	12.2	+0.55

chlorid of the diet does not increase the sodium chlorid concentration of the urine, but in order to get rid of the excess of the salt, the quantity of urine excreted is greatly increased.

The significance of the results tabulated in Table 2 can be appreciated more readily when they are compared with Table 3 taken from Erich Meyers'[30] article.

It may be readily noted from Table 2 that the concentration of sodium chlorid in the urine was not affected by the addition of 6 gm. sodium chlorid to the diet on the third day and the eighth day of the experiment. These results agree with those obtained by Meyer, showing that the kidneys of this individual have lost the normal power of concentrating the urine.

29. Gerhardt: Diabetes Insipidus, Modern Clinical Medicine, 1911, 113.
30. Meyer, Erich: Deutsch. Klin., 1910, xiii, Supplement No. 2, p. 271.

Garrod[31] also mentions the fact that observations carried out by Roberts under Garrod's direction on children suffering from diabetes insipidus tend to confirm Meyer's results, which were based on adult cases.

TABLE 2.—THE CHLORID METABOLISM

Day	Volume of Urine, C.c.	Specific Gravity of Urine	△* of Urine	Sodium Chlorid Content of Urine		Sodium Chlorid Intake, Gm.
				Gm.	Per Cent.	
1	1,800	1.005	0.24	2.08	0.110	3.4
2	3,080	1.005	0.22	3.38	0.110	3.5
3	3,080	1.005	0.25	3.32	0.108	9.5
4	4,000	1.003	0.27	4.10	0.102	3.4
5	5,190	1.002	0.22	5.36	0.103	3.4
6	4,305	1.002	0.26	4.70	0.109	3.4
7	4,400	1.002	0.28	4.40	0.100	3.4
8	4,260	1.003	0.24	4.66	0.109	9.6
9	5,500	1.002	0.22	5.56	0.101	3.5

* Freezing point of urine.

TALBE 3.—BEHAVIOR OF AN INDIVIDUAL WITH HEALTHY KIDNEYS ON THE ADDITION OF A SINGLE QUANTITY OF SODIUM CHLORID TO A STANDARD DIET

Volume of Urine, C.c.	Specific Gravity	△* of Urine	Sodium Chlorid		Remarks
			Per Cent.	Grams	
1,375	1.011	0.78	0.198	2.72	
1,200	1.011	0.91	0.444	5.38	10 gm. sodium chlorid added to diet
1,700	1.012	0.88	0.374	6.36	
1,450	1.010	0.75	0.316	4.48	

* Freezing point of urine.

In the earlier literature it was claimed that the chlorid output is increased in diabetes insipidus. Oppenheim,[32] however, shows that it has never been proved that this is due to anything but the sodium chlorid contained in the diet. Ferranini[33] has described two cases in which there was a marked increase in the excretion of sodium chlorid.

31. Garrod: In Diseases of Children, edited by Garrod, Batten, and Thursfield, 1914, 593.
32. Oppenheim: Ztschr. f. klin. Med., 1892. v, 618; Ibid., 1893, vi, 256.
33. Ferranini: Footnote 27.

TABLE 4.—The Sulphur Metabolism and Urinary Sulphur Partition

Day	Total Sulphur, Gm.	Total Sulphate Sulphur		Ethereal Sulphate Sulphur		Inorganic Sulphate Sulphur		Neutral Sulphur		Feces Sulphur, Gm.	Balance	
		Gm.	Per Cent. of Total Sulphur	Gm.	Per Cent. of Total Sulphur	Gm.	Per Cent. of Total Sulphur	Gm.	Per Cent. of Total Sulphur		Sulphur Intake, Gm.	Sulphur Balance, Gm.
1	0.49	0.42	85.7	0.03	6.1	0.39	79.6	0.07	14.3	0.14	0.80	+0.17
2	0.76	0.71	93.4	0.09	11.8	0.62	81.6	0.05	6.6	0.16	0.85	−0.07
3	0.55	0.50	90.9	0.06	10.9	0.44	80.0	0.05	9.1	0.17	0.82	+0.10
4	0.72	0.62	86.1	0.02	2.8	0.60	83.3	0.10	13.9	0.14	0.84	−0.02
5	0.71	0.63	88.7	0.02	2.9	0.61	85.8	0.08	11.2	0.22	0.98	+0.05
6	0.85	0.76	89.4	0.03	3.5	0.73	85.9	0.09	10.6	0.25	1.15	+0.05
7	0.79	0.72	91.1	0.02	2.5	0.70	88.6	0.07	8.9	0.23	1.14	+0.12
8	0.90	0.80	88.8	0.08	8.8	0.72	80.0	0.10	11.1	0.22	1.18	+0.06
9	0.71	0.61	85.9	0.05	7.0	0.56	78.9	0.10	14.1	0.24	1.09	+0.14

TABLE 5.—The Calcium, Magnesium, and Phosphorus Metabolism

Day	Urine			Feces			Intake			Balance		
	Calcium Oxid, Gm.	Magnesium Oxid, Gm.	Phosphorus, Gm.	Calcium Oxid, Gm.	Magnesium Oxid, Gm.	Phosphorus, Gm.	Calcium Oxid, Gm.	Magnesium Oxid, Gm.	Phosphorus, Gm.	Calcium Oxid, Gm.	Magnesium Oxid, Gm.	Phosphorus, Gm.
1	0.177	0.056	1.13	0.54	0.06	0.70	0.82	0.103	1.90	+0.103	−0.013	+0.07
3	0.360	0.120	1.52	1.02	0.15	0.62	0.86	0.16	2.12	−0.52	−0.12	−0.02
3	0.196	0.072	1.31	0.61	0.09	0.64	0.72	0.18	2.16	−0.086	−0.013	+0.21
4	0.249	0.094	1.35	0.60	0.09	0.71	0.89	0.20	2.22	+0.041	+0.016	+0.16
5	0.183	0.086	1.41	0.57	0.08	0.65	0.85	0.20	2.24	+0.097	+0.034	+0.18
6	0.354	0.116	1.21	0.91	0.12	0.91	1.20	0.26	2.12	−0.064	+0.024	0
7	0.100	0.049	1.90	0.95	0.06	0.98	1.30	0.25	2.86	+0.25	+0.141	−0.02
8	0.100	0.051	1.75	0.88	0.06	0.92	1.21	0.20	2.82	+0.23	+0.089	+0.15
9	0.310	0.114	1.73	0.86	0.13	0.95	1.18	0.20	2.80	+0.02	−0.034	+0.12

Vannini and also ourselves have found a normal output of sodium chlorid in the urine.

It will be seen by Table 4 that in the nine days' study there was a retention of 0.60 gm. sulphur, as would be expected on account of the nitrogen retention.

The total sulphate sulphur, ethereal sulphate sulphur, inorganic sulphate sulphur, and neutral sulphur are normal in amount and in percentage of the total urinary sulphur. Vannini has also found that the excretion of sulphates runs parallel with that of the protein catabolism in this condition. He also found normal values for the urinary ethereal sulphates.

According to Table 5 in the nine days' study there was a retention of 0.71 gm. calcium oxid, 0.124 gm. magnesium oxid and 0.83 gm. phosphorus. The percentage distribution of calcium, magnesium and phosphorus in the urine and stool is normal in amount.

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A STUDY OF THE ETIOLOGY OF CHOREA*

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This study was undertaken primarily to determine, if possible, the parts which syphilis and bacterial infection play in the etiology of chorea. Several other subjects, such as the relative frequency of endocarditis and rheumatism in association with chorea and the frequency with which possible foci of infection, such as diseased tonsils and carious teeth, are present in chorea, have also been incidentally investigated. The spinal fluid has also been studied in a number of instances. Twenty-six children, eleven boys and fifteen girls, were studied, their ages varying between 3 and 11 years. One of the children died of chorea and several had a very severe type of the disease, but the course was mild or moderate in the remainder.

THE RÔLE OF SYPHILIS IN THE ETIOLOGY OF CHOREA

According to Flatau,[1] Kowalewsly was the first to call attention to the possible etiologic relation of syphilis to chorea. It was Milian,[2] however, who started the discussion of this question. He presented two girls with chorea, showing evidences of syphilis and having positive Wassermann reaction, before the Medical Society of the Hospital of Paris in 1912. Under syphilitic treatment one of these recovered promptly and the other improved. He argued from these cases that syphilis might be the cause of chorea. A few months later he[3] reported the results of the Wassermann test in thirteen cases of chorea. It was strongly positive in five, partially positive in three, a total of 61.53 per cent., and negative in five. He also studied these cases and two others as to evidences pointing to hereditary syphilis and stigmata

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1. Flatau: Arch. f. Psychiat., 1894, xxvi, 552.
2. Milian: Bull. et mém. Soc. méd. d. hôp. de Paris, 1912, Series 3, xxxiii, 955.
3. Milian: Bull. et mém. Soc. méd. d. hôp. de Paris, 1912, Series 3, xxxiv, 628.

of syphilis. He came to the conclusion that the evidence in favor of syphilis was certain in eleven, or 73.33 per cent., probable in two, or 13.33 per cent., and doubtful in two, or 13.33 per cent. The data on which he based his conclusions do not in many instances, however, justify these conclusions to the unprejudiced observer. His paper aroused much discussion, most of which was unfavorable. Comby argued that the presence of a positive tuberculin test would be as good evidence in favor of the tubercular origin of chorea as a positive Wassermann test of the syphilitic origin. He also argued that the fact that both chorea and syphilis are helped by arsenic shows nothing as to the syphilitic origin of chorea. Guillian said that the pathologic anatomy of chorea is not that of syphilis and that syphilis of the nervous system does not act like chorea.

Babonneix[4] then looked over the histories of the last 145 cases of chorea in Hutinel's service and found reasons to justify the thought of congenital syphilis in only thirty-six, or 25 per cent. He remarks that these cases show little as to the etiologic relation of syphilis to chorea and calls attention to the fact that there was sufficient in the histories or physical examinations of the cases of pneumonia to justify a suspicion of syphilis in 18 per cent.

Grabois[5] also tabulated Hutinel's cases, including those of the year following the study of Babonneix, and found thirty-four of 136 cases, or 25 per cent., in which syphilis might be thought of. Certain evidence of syphilitic inheritance was present in but three, or 2.2 per cent., while there was presumptive evidence in twenty-eight, or 20.5 per cent. The Wassermann test was positive in but one of the four cases in which it was tried. Moreover, rheumatism was present in 23.5 per cent. and heart disease in 32.3 per cent. of the cases of chorea in which syphilis might be suspected.

Milian[6] continued his investigations and in 1914 was apparently of the opinion that all cases of chorea are syphilitic in origin. He argued, in connection with a case reported by Grenet and Sédillot[7] that a negative Wassermann reaction does not exclude syphilis. A striking thing in all of Milian's work is the lack of Wassermann tests, which were very seldom made.

Comby,[8] as the result of Milian's statistics and opinions, studied thirty-three cases of chorea in girls between 5 and 15 years of age,

4. Babonneix: Bull. et mém. Soc. méd. d. hôp. de Paris, 1912, Series 3, xxxiv, 671.

5. Grabois: Thèse de Paris, 1913, No. 298.

6. Milian: Bull. et mém. Soc. méd. d. hôp. de Paris, 1914, Series 3, xxxvii, 368.

7. Grenet and Sédillot: Bull. et mém. Soc. méd. d. hôp. de Paris, 1913, Series 3, xxxv, 73.

8. Comby: Bull. et mém. Soc. méd. d. hôp. de Paris, 1915, Series 3, xxxix, 238.

whom he treated and cured in 1913, 1914 and early 1915. Stigmata of syphilis were present in four and the mothers of seven others had had frequent miscarriages. The Wassermann test on the blood was positive in six, feeble or doubtful in four and negative in twenty-three. The cutaneous tuberculin test was positive in twenty and negative in eleven. He concludes that there is more reason for believing that latent tuberculosis is the cause of chorea than there is for attributing it to syphilis, and states that all that the positive Wassermann tests and the presence of a history suggestive of syphilis or of stigmata of the disease show is that a certain proportion of children with chorea also have syphilis. He does not deny that syphilitic infection may play a part in the production of chorea and believes that the encephalitis of chorea may be due to a variety of causes, among which may be syphilis.

Comby's[9] results having been criticized on the ground that the Wassermann test is sometimes positive in the cerebrospinal fluid when it is negative in the blood; he tested both the cerebrospinal fluid and the blood in seven cases. The Wassermann test was negative in the cerebrospinal fluid in all, while it was positive in the blood in one. It is worthy of note in this connection that Marie and Chatelin* got negative tests in the cerebrospinal fluid in eight and Merklen[10] in one case of chorea.

Koplik[11] made Wassermann tests on the blood in ten cases of chorea and got negative results in eight. The test was unsatisfactory, but not positive, in the others. There was nothing to suggest syphilis in the histories or physical examinations of any of them.

Salvarsan and Neosalvarsan Treatment.—Salvarsan was first used in the treatment of chorea because of the supposed favorable action of arsenic in this disease, on the basis that, this being the most powerful preparation of arsenic, it should give better results than the other forms of the drug. It was not long, however, before it was used because of the belief of some that chorea is a manifestation of syphilis. Much has been written about the use of salvarsan in this connection on a very slight basis of facts.

Salinger,[12] writing in June, 1912, was able to collect but ten cases treated with salvarsan, those of Bokay, Hainess, Mayerhofer, Dufour and Low, Hahn and his own. Szametz[13] used it in one case, presumably not syphilitic, with good results, while Flatau[14] used it ineffec-

* Reference given in Footnote 15.

9. Comby: Bull. et mém. Soc. méd. d. hôp. de Paris, 1915, Series 3, xxxix, 666.
10. Merklen: Bull. et mém. Soc. méd. d. hôp. de Paris, 1912, Series 3, xxxiv, 628.
11. Koplik: Arch. Pediat., 1915, xxxii, 561.
12. Salinger: München. med. Wchnschr., 1912, lviii, 25.
13. Szametz: München. med. Wchnschr., 1912, lix, 2333.
14. Flatau: München. med. Wchnschr., 1912, lix, 2102.

tually in a chronic case, unquestionably syphilitic, as the patient was relieved by mercury.

Marie and Chatelin[15] treated twenty-five patients for chorea with intravenous injections of salvarsan, obtaining favorable results. In eight cases, in which the Wassermann test was tried with the cerebrospinal fluid, negative results were shown. They do not believe that the reason salvarsan does good in chorea is because chorea is syphilitic in origin, but because of the parasiticidal action of the arsenic.

Koplik[11] treated nine patients with neosalvarsan, getting no effect in seven; one developed nephritis, and another had a relapse.

A number of authors have claimed favorable results also from the use of salvarsan by the rectum. This method of treatment is hardly worthy of consideration in comparison with the intravenous method. If salvarsan and neosalvarsan are to be given at all, they should be given intravenously.

It seems clear, therefore, from a study of the literature, that there is very little evidence in favor of the syphilitic origin of chorea and much against it.

Original Investigations.—There was nothing whatever in the history of twenty-one, or 81 per cent., of our twenty-six patients to suggest syphilis. In the others there was a history of miscarriages, two in six pregnancies, one in eleven, one in four, four in five, and five in eleven pregnancies. No one of the patients was born prematurely. The blood of three of the five children in whose families there was a history of miscarriages gave a negative Wassermann test, the spinal fluid not being tested in these cases. The blood of one gave a positive Wassermann test; the spinal fluid was not tested in this instance. The blood of the other gave a doubtful reaction on three occasions, while the spinal fluid was negative at one examination. These two children were the only ones that gave either a positive or a questionable Wassermann test in the whole series.

None of the twenty-six children showed any stigmata of syphilis. The Wassermann test was done at the Wassermann laboratory of the Massachusetts State Board of Health on the blood of twenty-five of the twenty-six patients. It was negative in twenty-three, or 92 per cent. It was positive in one, and doubtful in another on three occasions. The Wassermann test was tried on the cerebrospinal fluid, obtained by lumbar puncture, on eight patients. It was negative in all.

Granting that a negative Wassermann test does not absolutely exclude syphilis, it is, nevertheless, very strong evidence against it, so strong that it practically excludes syphilis as the cause of the chorea

15. Marie and Chatelin: Bull. de l'Acad. de méd., Paris, 1912, Series 3, lxviii, 507.

in twenty-three of these patients. The case against syphilis as the cause of the chorea in these twenty-three children is further strengthened by the facts that none of them presented any of the stigmata of syphilis and in only three of them was there anything in the family history even remotely suggesting syphilis. The presence of a positive Wassermann reaction in one instance and a doubtful one in another does not prove that syphilis was the cause of the chorea in these children, because that proportion of positive and doubtful reactions is no higher than the average for the hospital class of children in Boston and vicinity, and probably not so high. Moreover, the test was negative in the spinal fluid of the child in whom the test was doubtful in the blood, when it would naturally be expected to be more marked in the spinal fluid than in the blood, if syphilis was the cause of the chorea. The spinal fluid was unfortunately not examined in the other case. Furthermore, as Comby has said, a positive Wassermann test in a child with chorea does not prove that the chorea is due to syphilis any more than a positive tuberculin test proves that it is due to tuberculosis. As a matter of fact, twenty-one, or 84 per cent., of the twenty-five children in this series in which the skin tuberculin test was done showed a positive reaction. It would be absurd to assume that tuberculosis was the cause of the chorea in these twenty-one children. A study of these cases justifies the conclusion, therefore, that syphilis seldom, if ever, plays an active part in the etiology of chorea.

THE RÔLE OF BACTERIA IN THE ETIOLOGY OF CHOREA

The close clinical relationship between acute articular rheumatism, endocarditis and chorea, taken in connection with the present conception that acute articular rheumatism and acute endocarditis are bacterial in origin, has suggested that chorea is also bacterial in origin and perhaps caused by the same or a similar organism. Further evidence pointing in the same direction is the frequency with which local foci of infection, notably in the tonsils or in and about the teeth, are found in all of these conditions. For these reasons an increasing number of investigations directed toward the discovery of such an organism or group of organisms have been undertaken during recent years.

Our patients confirm the general belief as to the frequency of the association of chorea with rheumatism and endocarditis, seven of them, or 37 per cent., having had rheumatism in the past or with the chorea. Six of them had acute endocarditis and six chronic valvular lesions, a total of twelve, or 46 per cent. They show also the frequency with which local foci of infection are found in the mouth and throat in chorea. The tonsils were normal in but eleven cases, while they were diseased in eleven, or 42 per cent., and had been removed on account of disease in four others. The teeth were normal in but seven and

were carious in nineteen, or 73 per cent. Pyorrhea was present in two of these children and definite pus pockets were found in three others when the teeth were extracted.

A number of investigators have found bacteria in the central nervous system in fatal cases of chorea. Among them may be mentioned Westphall, Wassermann and Malkoff,[16] who isolated a diplococcus from the cerebrospinal fluid and with it consistently produced polyarthritis in rabbits. Poynton and Payne[17] also isolated and cultivated a diplococcus from the cerebrospinal fluid in four cases of fatal rheumatism, in three of which there was chorea at the time of death. They produced twitching movements, arthritis, endocarditis and pericarditis by the intravenous injection of this organism into rabbits. They also demonstrated the presence of this same diplococcus three times in the cerebral pia mater and once in the brain in cases of chorea. They also found them in the brain and pia mater of a rabbit that had shown twitching of the muscles.

Bacteriology of the Blood in Chorea.—Other investigators have found micro-organisms in the blood during life. Camisa[18] gives seventeen references to authors who have found microorganisms in the blood of patients with chorea. They were usually found in only one or, at most, three cases. The organisms found were very different—bacilli, staphylococci, diplococci, streptococci. He studied the blood taken from the veins in nine patients varying in age from 6 to 16 years. It is to be noted that they all showed evidences of cardiac lesions. He found a diplostreptococcus, forming short chains, in six cases. The morphologic and cultural characteristics of the organism were the same in all cases. The blood serum of patients with chorea at the height of the disease agglutinated this organism to a moderate degree, more than it did the ordinary pus streptococci. The agglutinating power of the blood diminished with improvement of the symptoms. This agglutinating power was not specific, however, as the organism was agglutinated more strongly by the serum of a typhoid patient. Animal experiments were negative. He believes that this organism is the cause of chorea, but admits that it is possible that chorea may also be caused by other organisms.

Donath[19] studied seven cases of very severe chorea, two of which were fatal. He found the *Staphylococcus pyogenes-albus* in the blood in four cases and in the brain in one case, and the *Staphylococcus pyogenes-aureus* in the blood in one case and the cerebrospinal fluid in

16. Westphall, Wassermann and Malkoff: Berl. klin. Wchnschr., 1899, xxxvi, 638.
17. Poynton and Payne: Lancet, London, 1905, ii, 1760.
18. Camisa: Centralbl. f. Bakteriol., Orig., 1910-1911, lvii, 99.
19. Donath: Ztschr. f. d. ges. Neurol. u. Psychiat., Orig., 1910-1911, iv, 91.

another. Animal experiments were inconclusive. He is inclined to think that the staphylococci found were of pathogenic significance, but does not ascribe any specificity to them.

Collins[20] obtained a pure culture of a diplococcus from the blood of a girl ill with chorea. This organism grew in twos and formed short chains of from four to six pairs. A vaccine was prepared from it, which, in his opinion, had a favorable influence on the course of the disease.

Richards[21] made blood cultures from the veins in two cases of chorea. It is to be noted that one of the patients had chronic endocarditis, acute arthritis and pyorrhea alveolaris, while the other had chronic endocarditis and had had tonsillitis. He found the *Streptococcus viridans* in both. He says that there is "no doubt that this coccus found in the blood is associated with endocarditis, but that it is the etiologic factor sine qua non in chorea is not proved."

La Fétra[22] in the discussion of a paper by Strauss stated that he had found the *Streptococcus viridans* in two cases of chorea at the Bellevue Hospital and that complement deviation tests were positive in two others. He does not state in how many instances he obtained negative results. Bartley, in the same discussion, stated that tests made in three or four cases at the Long Island College Hospital were negative.

Koplik[11] states that he has had the blood diligently cultivated in many cases of chorea, but that he has failed to isolate any organisms.

It is evident that the results thus far obtained from blood cultures in chorea are inconsistent and inconclusive. In almost every case in which organisms have been found there has been some other complicating condition amply sufficient to account for the presence of organisms in the blood. Their presence, therefore, has not proved that they were the cause of the chorea. The absence of organisms in the blood does not prove, however, that chorea is not caused by bacteria, because, although the cause of the disease, they may have been absent from the blood at the time the cultures were made, and the methods of cultivation used may not have been suitable for the growth of the organisms, if present.

Bacteriology of the Cerebrospinal Fluid in Chorea.—There are practically no data as to the bacteriology of the cerebrospinal fluid in chorea during life. Donath[19] found the *Staphylococcus aureus* in one case, while Passini[23] found the cerebrospinal fluid sterile in five cases. Collins[20] has reported a case of chorea as cured by treatment with an

20. Collins: Brit. Med. Jour., 1913, i, 220.
21. Richards: Jour. Am. Med. Assn., 1914, lxii, 110.
22. La Fétra: Arch. Pediat., 1915, xxxii, 135.
23. Passini: Wien. klin. Wchnschr., 1914, xxvii, 1363.

autogenous vaccine prepared from a coccus obtained by lumbar puncture.

Original Investigations.—We have made during the past year a bacteriologic study of twenty-six cases of chorea in the acute stage of the disease with a view to determining the presence of an infecting agent in the blood stream and cerebrospinal fluid, the frequency with which it could be obtained, and its cultural characteristics. The cerebrospinal fluid was obtained by lumbar puncture under an anesthetic and with sterile precautions twenty times in nineteen cases. The blood was obtained from one of the veins of the arm with sterile precautions, sometimes under an anesthetic and sometimes not, thirty-one times in twenty-six cases.

About 5 c.c. of cerebrospinal fluid and 5 c.c. of blood were secured when it was possible. The blood was immediately put into a series of different kinds of mediums and incubated for two weeks. During this time frequent examinations of the cultures were made and fresh transfers were inoculated. The cerebrospinal fluid was similarly treated. The mediums used consisted of blood dextrose agar, Loeffler's blood serum, neutral and acid milk, serum water dextrose, lactose, and saccharose, dextrose bouillon, and at times hydrocele fluid alone and with agar. Aerobic and anaerobic methods were both used. Blood was also drawn into citrated saline solution and centrifuged. The sediment was planted and smears made for examination. In every instance the cultures, as well as smears from the cerebrospinal fluid, were negative. Blood cultures were negative in twenty-six instances, even after several weeks of incubation and subculturing. In five cases organisms were obtained. In one case a small bacillus, diphtheroid in type, appeared, giving a fine, pinpoint, moist growth on blood serum at the end of a week. This organism grew very slowly on agar and failed to produce any reaction in solutions of serum water containing saccharose, lactose, mannite, raffinose, dextrose, inulin, and maltose. It was gram negative and was not pathogenic for rabbits even when large doses were given intravenously. In this instance the tonsils were large and the teeth were slightly carious. The heart was normal and there were no rheumatic symptoms.

Diplococci were found in the blood smears in one case, but no organisms were cultivated. In this instance the tonsils were submerged and there were several carious teeth, one of which had a pocket of pus about its root. The heart was normal and there were no symptoms of rheumatism.

In two other cases short chains of cocci appeared in litmus milk in the initial culture, but all efforts of subculturing failed. The tonsils were normal in both of these cases, but the teeth were carious. The heart was normal in both and neither showed any evidences of rheumatism.

In another case positive blood serum cultures were obtained after ten days of incubation. In this instance the tonsils and adenoids had been removed, but the teeth were carious. The patient had acute endocarditis and had had several attacks of rheumatism. The first colonies appearing were flat, colorless and disklike. Smears showed these to be made up of long chains of a fine gram-positive streptococcus. Subcultures were at first obtained with difficulty. This organism produced a slight greenish-yellow zone of hemolysis on blood agar plates, fermented saccharose and dextrose in serum water cultures, did not acidulate or coagulate milk, and failed to act upon lactose, mannite, raffinose, inulin, and maltose. This organism is now readily subcultured and its early characteristics have remained unchanged through ten generations. Intravenous inoculations in two rabbits in doses of from 2 to 3 c.c. of a thick suspension of the organism killed the animals in from twenty-four to forty-eight hours. Necropsies showed a general septicemia, and cultures from the heart's blood and knee joints gave a good growth of streptococci. Four other large rabbits were given a series of intravenous inoculations of from 0.5 to 1 c.c. of a heavy suspension of the organism at an interval of from three to five days. Three were killed at intervals of from ten to thirty days. All the animals lost weight and, with the exception of Rabbit 6, which died after five days, they all showed lameness and difficulty in walking and standing and restlessness on handling of the joints. Some swelling of the knees was also noted.

PROTOCOLS

RABBIT 3.—Large white male, showing considerable loss of weight. Opening of the knee joint showed a smooth, glistening surface. There was a moderate amount of fluid in both joints, sticky and turbid. Smears showed numerous leukocytes and chains of streptococci. A good growth was obtained on culture.

The heart cultures gave streptococci. The organ was filled with postmortem clot, but the valves and endocardium were negative. The brain was not examined.

RABBIT 4.—A medium-sized brown male, showing marked loss of weight, was given four inoculations in three weeks' time, each dose consisting of 1 c.c. of saline suspension. The animal was killed while moribund. For two weeks there had been apparent pain and limitation of motion in both knee and hip joints. The knee joints showed a turbid, sticky fluid containing numerous leukocytes and streptococci. Cultures gave the organism in pure culture.

The heart was negative. Cultures from the heart's blood gave chains of streptococci.

The dural and pial vessels about the brain were much engorged. No thickening or exudation was found. Smears gave streptococci in chains, but cultures were negative. Sections were hardened in 80 per cent. alcohol and stained with hematoxylin, eosin and Giemsa stain. Marked round-cell infiltration of the pia extending slightly into the brain substance was noted. There was some increase of leukocytes. No organisms were found.

RABBIT 5.—A large brown and white female was given a series of intravenous inoculations of a heavy saline suspension of streptococcus over a period

of five weeks. Marked crippling of the joints of the fore and the hind legs was noted. The animal was killed while in fairly good condition. The heart valves and endocardium were negative. Smears and cultures from the heart's blood were negative. The pial vessels were slightly distended. Smears and cultures were negative. The knee joints both contained a thick, sticky fluid, the left capsule being distended with it. Smears showed numerous leukocytes and chains of streptococci. Cultures of streptococci were readily obtained. Sections of the brain showed marked round-cell infiltration of the pia over the cortex and extending generally into the convolutions. No organisms were seen.

RABBIT 6.—A large, white male rabbit was given 1.5 c.c. intravenously of a heavy saline suspension of streptococci obtained from the knee joint of Rabbit 5. The animal lived four days and then died. The heart showed some enlargement. The valves were negative macroscopically. Scattered over the endocardium, especially in the wall of the left ventricle, were small white areas about 0.1 to 0.2 cm. in diameter. The largest area, 0.2 cm. in diameter, near the mitral orifice, gave a good growth of streptococci on culture. Cultures from the heart's blood were positive for streptococci.

Examination of the brain showed distention of the pial vessels. Smears and cultures from the cortex showed streptococci in abundance.

A series of agglutination tests was carried out, by using a suspension of the organism, together with blood serum or cerebrospinal fluid from eight patients with active chorea. No positive results were obtained.

COMMENT

It is difficult to draw any positive conclusions from the results of our work as to the part which bacteria play in the etiology of chorea. In view of the fact that the diphtheroid bacillus isolated from the first patient was nonpathogenic for rabbits, it seems very improbable that it played any part in the etiology of the chorea in this instance. It seems probable that the cocci which developed in the initial cultures from the third and fourth patients were the same as those which were cultivated in the fifth. There is, however, absolutely no proof that this is so; it is merely a supposition. The diplococcus found in the blood smears from the second patient was evidently a different organism. The fact that the streptococcus obtained from the fifth patient caused lesions in the endocardium and joints of rabbits makes it very probable that it was the cause of the endocarditis in the child. The fact that it caused lesions in the brain and meninges of rabbits, similar to those found in the brain and meninges of fatal cases of chorea, suggests that it was also the cause of the chorea in the child. Further than this it is not safe to go. It must also be remembered that there was a local focus of infection in all the cases in which cocci were found in the blood, and that the microorganisms might have been derived from this focus and have had no etiologic connection with the chorea. The absence of organisms in the cerebrospinal fluid in all of the cases in which it was examined is also an argument against the bacterial origin of chorea, because it would seem reasonable to suppose that in a disease in which lesions are located in the nervous system the causative organism would be more constantly present and more abundant in the cere-

brospinal fluid than in the blood. The absence of organisms in the cerebrospinal fluid and in the blood of most of the patients in this series may be explained, however, by the fact that the majority of the cases were mild or only moderately severe in type. It is also possible that the failure to detect organisms more often, either in smears or cultures from the blood, may have been due to the fact that they are only temporarily present in the blood stream and tend to locate themselves in the meninges, endocardium or joints. If this is so, the opportunity of securing a positive culture from the blood is small, even if repeated invasions of the blood occur.

The conclusion seems justified, therefore, both from the study of the literature and from our own work, that while there is much which points to a microorganism or a group of organisms as the cause of chorea, the bacterial origin of chorea has not yet been proved.

THE CEREBROSPINAL FLUID IN CHOREA

Most of the studies of the cerebrospinal fluid in chorea have been made by French observers. The fluid was studied and the cells counted in most instances in order to prove or disprove the organic nature of chorea, a discussion of which was going on at the time. Dupré and Camus[24] found a very distinct lymphocytosis in the cerebrospinal fluid obtained by lumbar puncture from a boy of 18 years, ill with a very severe chorea. Babonneix[25] found a lymphocytosis in two of five cases. Sicard[26] is said to have found a distinct lymphocytosis in a severe febrile case, which was still present after six weeks. Thomas and Tinel[27] found a distinct lymphocytosis in a girl of 13, ill three months with chorea. They[28] found a similar condition in two of four other patients examined a few months later. Claude[29] found a lymphocytosis of six or eight cells to a field in one of two children of 18 years after illness of four months. Gatow-Gatovski[30] did lumbar puncture in seven cases and found a distinct lymphocytosis in one and hypertension in one.

Richardière, Lemaire and Sourdel[31] found a lymphocytosis in twelve of fourteen cases and hypertension in ten. The symptoms were relieved somewhat by lumbar puncture in three cases. The fluid was centrifugalized and the drop at the bottom of the tube examined with an oil immersion lens. The decision as to the presence or absence of

24. Dupré and Camus: Bull. et mém. Soc. méd. d. hôp. de Paris, 1904, xxi, 361.
25. Babonneix: Traité des maladies de l'enfance d'Hutinel, p. 745.
26. Quoted by several authors, reference not given.
27. Thomas and Tinel: Rev. neurol., 1909, xvii, 638.
28. Thomas and Tinel: Rev. neurol., 1909, xvii, 1060.
29. Claude: Rev. neurol., 1909, xvii, 931.
30. Gatow-Gatovski: Thèse de Paris, 1910, p. 386.
31. Richardière, Lamaire and Sourdel: Ann. de méd. et chir. inf., 1911, xv, 276.

a lymphocytosis depended on the number of cells seen per field. This is the method which was apparently used by all the French observers and does not seem at all exact. They conclude that there is almost constantly a lymphocytosis in the cerebrospinal fluid in acute chorea and that it is the most constant of the signs of an organic lesion yet discovered.

Negative results were obtained by many other observers. It is probable, moreover, that a much larger proportion of the positive than of the negative results have been recorded.

Deléarde and Valetti[32] found a lymphocytosis in one of ten cases. There was hypertension in some cases. They think that this is of no diagnostic importance, because hypertension is present in many diseased conditions. Prolonged vomiting followed the punctures in several cases.

Comby[9] found 12 lymphocytes per c.mm. in one of seven cases. There was no excess in the others.

Original Investigations.—Lumbar puncture was done twenty times in nineteen of our cases. The cerebrospinal fluid was perfectly clear in every instance. The pressure was apparently slightly increased in one instance. It was normal in all the others. A fibrin clot was never formed. The number of cells per cubic centimeter was counted in ten cases, and was, respectively, 2, 5, 7, 8, 10, 10, 10, 18, 24 and 25. There was, therefore, a slight increase in the number of cells in three of the ten cases, or 30 per cent. The cells were all mononuclear in every case.

Lumbar puncture had no noticeable effect on the symptoms, either for better or worse, at the time or later, in any instance.

CONCLUSIONS

Our investigations show that syphilis plays no direct part in the etiology of chorea. Our results suggest that a microorganism or a group of microorganisms may be the cause of chorea. They seem to show that if chorea is caused by a microorganism, the source of infection is ordinarily in the tonsils or teeth. They tend to confirm the belief that there is an intimate relation between chorea, rheumatism and endocarditis.

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32. Deléarde and Valette: Arch. de méd. d. enfants, 1913, xvi, 481.

THE CURVED LINES OF SUCTION*

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With regard to the mechanism of an infant's suction, many problems still remain unsolved. According to the studies by Burdach,[1] Funke,[1] Meissner,[2] Allix[3] and Herz,[4] the negative pressure in an infant's oral cavity which is necessary for sucking milk is chiefly made by inspiratory action, while Biedert[5] and Vierordt[6] attribute it to the enlargement of the vertical diameter of the oral cavity, the lower jawbone being drawn downward. After detailed researches, Auerbach[7] in 1888 made a new discovery in connection with the physiology of suction in general. He divided the action into two kinds: (1) suction by inspiration, and (2) suction by the mouth, or the tongue.

Suction by inspiration is made by adults, and the negative pressure in the mouth necessary for suction is chiefly caused by inspiratory action; while suction by the mouth is made by infants, and the negative pressure in the mouth is chiefly due to the vertical diameter of the oral cavity being enlarged, because the lower jawbone is drawn downward. Auerbach's opinion is generally accepted now as true, that suction by the mouth does not change to suction by inspiration till an infant is two or three years old. Basch,[8] Pfaundler[9] and Süsswein,[10] who made further studies on the subject in later years, were of the same opinion, that is, that the negative pressure in the mouth when an infant sucks milk is chiefly attributable to the draw of the lower jawbone, and suction by inspiration is made by an adult, but not by an infant.

In respect to the change of the form of the tongue when milk is sucked and the effect which the change or the movements of the tongue has on the mechanism of suction, many authors seem to entertain different opinions. Auerbach says that the change in the

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1. Burdach, cited from Escherich: München med. Wchnschr., 1888, xli, 687.
2. Meissner: Lehrbuch der Kinderheilkunde.
3. Allix: Etude sur la physiologie, 1867, Paris.
4. Herz: Jahrb. f. Kinderh., 1865, vii, 46.
5. Biedert: Deutsch. Arch. f. klin. Med., 1875, xviii, 115.
6. Vierordt: In Gerhards Handbuch, I, 112.
7. Auerbach: Du-Bois Reymonds Arch. f. Physil., 1888, 59.
8. Basch: Arch. f. Gynäk., 1893, xlix, 15.
9. Pfaundler: Verhandlung d. Gesellsch. f. Kinderh., 1899.
10. Süsswein: Arch. f. Kinderh., 1904, xl, 68.

form of the tongue does not have much influence in the mechanism of suction; while Basch and Pfaundler attach importance to this change in the shape of the tongue in the suction of milk, as being a prominent feature of the mechanism. Basch observes that the suction of milk is accomplished not wholly by the negative pressure in an infant's mouth, but the act is assisted by the pressure of the nipple effected by the closure of the jawbones.

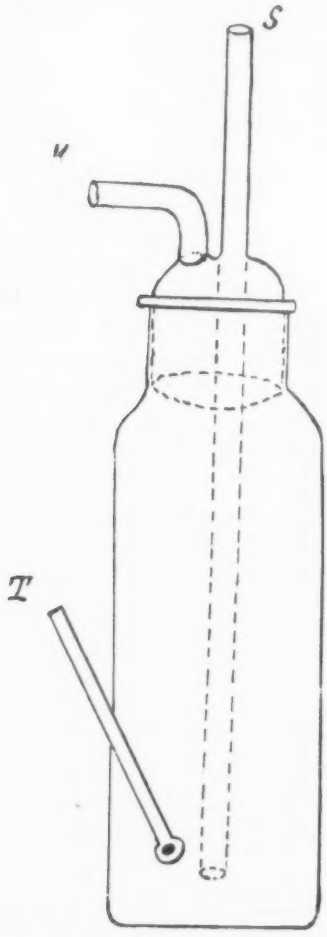

Fig. 1.—Drawing showing apparatus used as a nursing bottle in obtaining the records of the negative pressure of suction.

It is a generally known fact that infants possess certain anatomic features which nature has provided for performing the act of sucking milk. The gingivale and sucking-bolster (Bichat's bolster) might be mentioned, but it is not my intention to deal with them in detail now.

As regards an infant's suction, Herz,[4] Biedert,[5] Pfaundler,[9] Cramer,[11] Basch,[8] and Barth[12] studied it in their respective methods, but they simply measured, by means of some arrangements, the negative pressure in an infant's oral cavity necessary for the suction of milk.

I made, however, the following experiment in order to register by curved lines the change of the pressure:

Figure 1 shows a nursing bottle of from 100 to 150 c.c. capacity, which I used in my experiment. The glass tube *S* in the bottle, about 5 mm. in diameter, is connected at the upper end by means of a rubber tube with a nipple, such as is in common use. The glass tube *K*, 5 mm. in diameter, is connected with Marey's tambour by means of a rubber tube. *T* is a thermometer to show the temperature of the milk in the bottle.

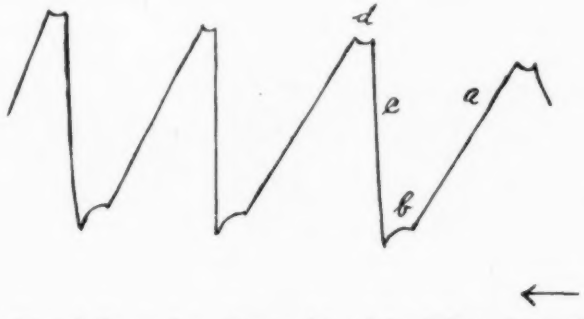

Fig. 2.—Curved lines of suction registered by infants in good health.

Milk of a certain temperature was put into the nursing bottle, and an infant was permitted to suck at the nipple with the result that every change of pressure in the oral cavity was given to Marey's tambour, and was registered on the blackened paper closely-attached to the kymograph. Jaquet's watch was used to measure the speed of the registering tube which was turning around. The child was put on its mother's knee, a little aslant in posture, with the kymograph back of the mother. The kymograph should be as noiseless as can be obtained. By this experiment were obtained the curved lines which I call the curved lines of suction.

I examined seventy-five infants in good health under artificial feeding and Figure 2 is a schema of the curved lines of suction registered by these infants. The milk in the nursing bottle had the temperature of 37 C., or thereabouts. The curved lines thus obtained can

11. Cramer: Zur Mechanik u. Physiologie d. Nahrungsaufnahme d. Neugeborenen.

12. Barth: Ztschr. f. Kinderh., 1914, x, 129.

be subdivided into four parts: (1) the descending part (*a*); (2) a small elevation (*b*); (3) the ascending part (*c*); (4) the notch (*d*).

1. The descending part of the curve represents the downward movement of the lower jawbone, the oral cavity being extended in the vertical diameter.

2. The small elevation is due to the pressure on the nipple attached to the rubber tube.

3. The ascending part of the curve may be attributed to the running down of the milk which has been taken into the mouth.

4. The notch is a concave curve caused by the swallowing.

The curved lines of suction above mentioned are made by most infants (Figs. 3 to 9), yet the small elevation is not always given clearly (Figs. 10 and 11). The notch varies with different postures of an infant, being clearer when the child lies down than when it sits.

Rarely the curved lines shown in Figures 12 to 14 are made by a healthy infant. In this case the ratio of the time required for sucking the milk to that for swallowing it is 2:1. These lines are so rare that only three of the seventy-five healthy infants made them in my experiments.

Healthy infants over a week old are always regular in making the curved lines of suction, and never discontinue to do so, while a newborn infant sometimes discontinues them for physiologic reasons (Figs. 15 to 18). In that case, as the figures show, a certain pause is made after regular curved lines of suction, but the lines are resumed after the pause. This physiologic pause, however, is to be seen no more when an infant is a week old.

An infant fed by its maternal breast and unaccustomed to sucking milk from the nipple attached to a rubber pipe makes irregular curved lines of suction at first (Figs. 19 to 22), but as soon as it is accustomed to that way of suction it will make regular lines.

I gave healthy infants milk of various degrees of temperature in order to determine, by studying the lines thus obtained, what relations there are between the curved lines of suction and the temperature of the milk.

The conclusion I arrived at was, as Figures 23 to 27 show, that the curved lines of suction are irregular when milk is below 20 C. or above 40 C, but regular and never discontinued when the temperature is between 30 and 40 C.

The curved lines of suction made by infants of premature birth and in atrophy are always remarkably irregular and often discontinued (Figs. 28 to 38), but become regular in proportion to the increase of the weight of the infant and the improvement of nutrition.

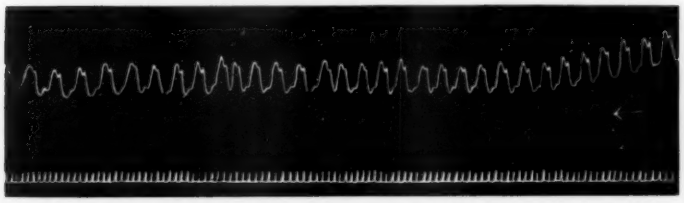

Fig. 3.—O. H., healthy infant, aged 2 months (time, one-fifth second).

Fig. 4.—J. S., healthy infant, aged 5 months (time, one-fifth second).

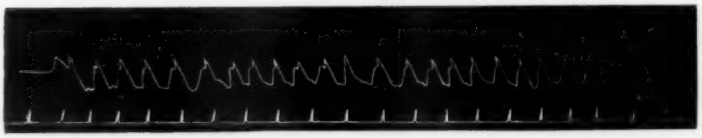

Fig. 5.—M. O., healthy infant, aged 6 months (time, one second).

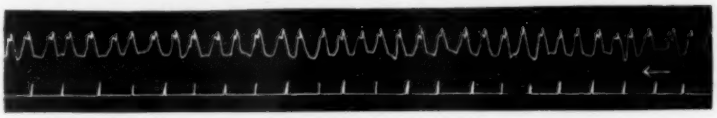

Fig. 6.—K. M., healthy infant, aged 1 month (time, one second).

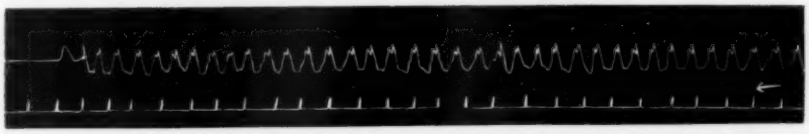

Fig. 7.—K. Y., healthy infant, aged 3 weeks (time, one second).

Fig. 8.—A. O., healthy infant, aged 1 week (time, one second).

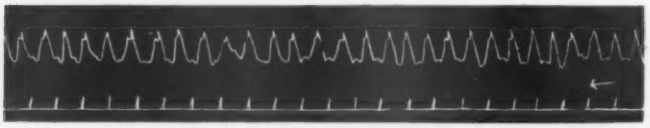

Fig. 9.—K. K., healthy infant, aged 2 weeks (time, one second).

Fig. 10.—G. I., healthy infant, aged 1½ months (time, one second).

Fig. 11.—K. T., healthy infant, aged 5 months (time, one second).

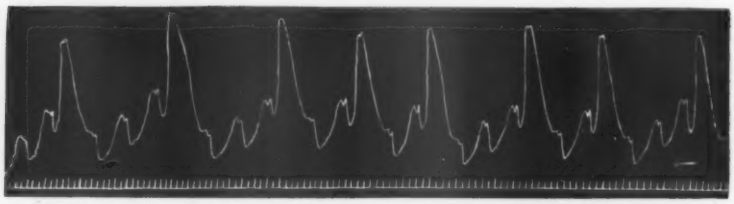

Fig. 12.—K. T., healthy infant, aged 6½ months (time, one-fifth second).

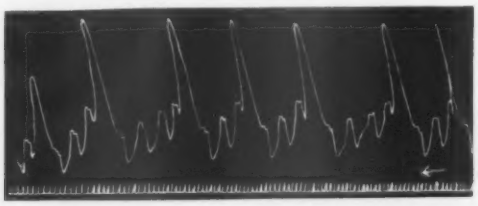

Fig. 13.—S. T., healthy infant, aged 3 months (time, one-fifth second).

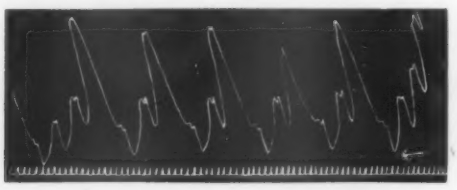

Fig. 14.—J. U., healthy infant, aged 2 months (time, one-fifth second).

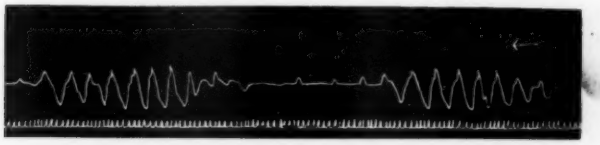

Fig. 15.—I. K., healthy newborn baby (time, one-fifth second).

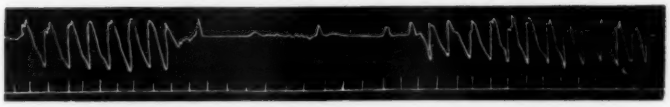

Fig. 16.—K. U., healthy newborn baby (time, one second).

Fig. 17.—M. G., healthy newborn baby (time, one second).

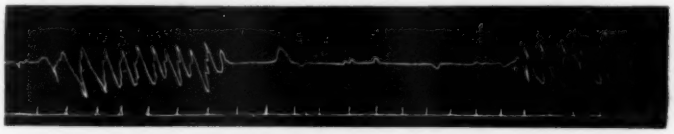

Fig. 18.—K. S., healthy newborn baby (time, one second).

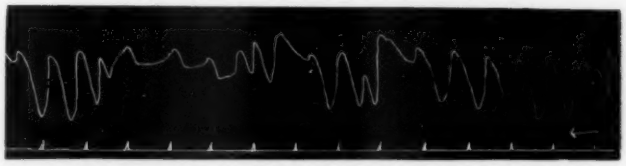

Fig. 19.—K. T., healthy breast-fed infant, aged 1 month (time, one second).

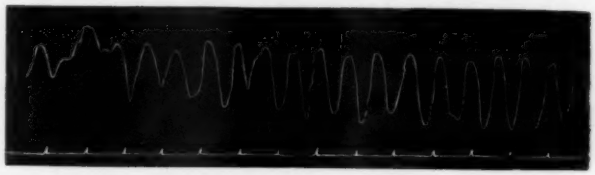

Fig. 20.—T. Y., healthy breast-fed infant, aged 3 months (time, one second).

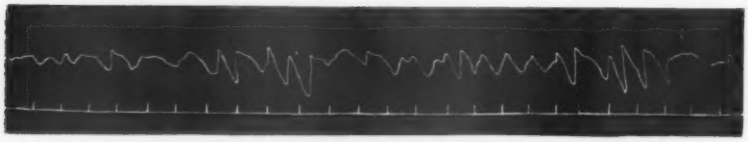

Fig. 21.—K. K., healthy breast-fed infant, aged 4 months (time, one second).

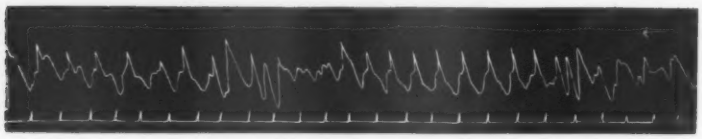

Fig. 22.—T. T., healthy breast-fed infant, aged 6 months (time, one second).

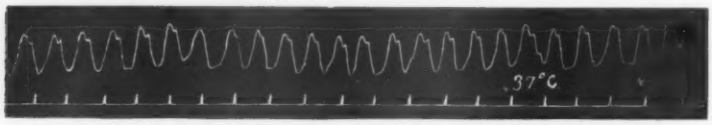

Fig. 23.—M. K., healthy infant, aged 3 months; the temperature of the milk 37 C. (time, one second).

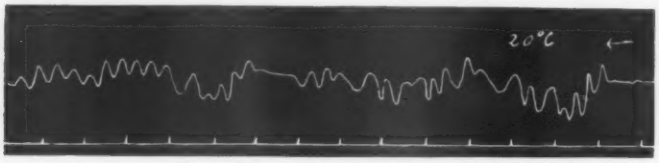

Fig. 24.—M. K. The temperature of the milk 20 C. (time, one second).

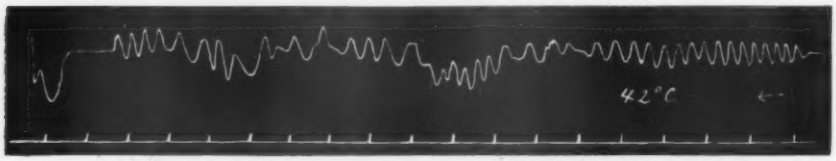

Fig. 25.—M. K. The temperature of the milk 42 C. (time, one second).

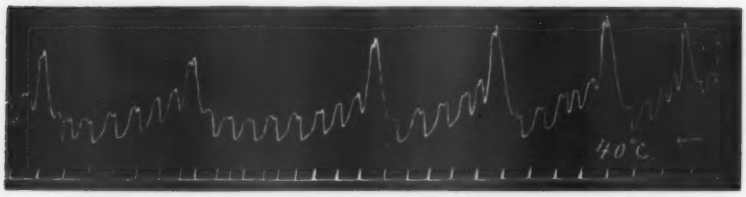

Fig. 26.—M. K. The temperature of the milk 40 C. (time, one second).

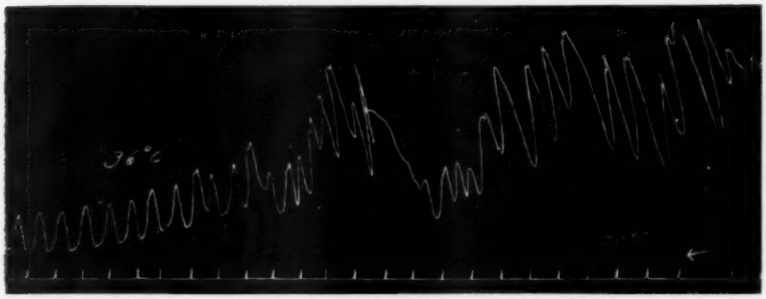

Fig. 27.—H. K., healthy infant, aged 2 months (time, one second).

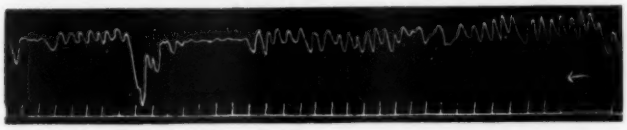

Fig. 28.—T. Y., infant of premature birth (time, one second).

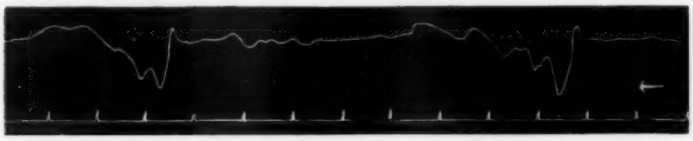

Fig. 29.—O. U., infant of premature birth (time, one second).

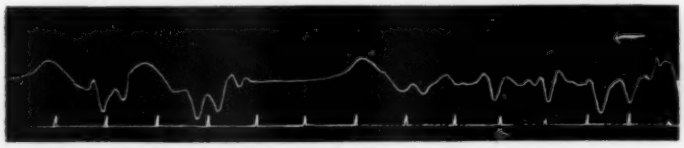

Fig. 30.—K. K., infant of premature birth (time, one second).

Fig. 31.—O. O., infant of premature birth (time, one second).

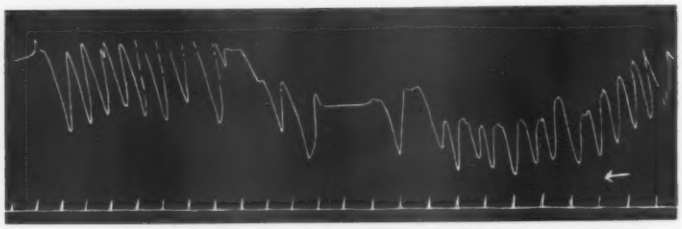

Fig. 32.—U. K., aged 3 months, weight 3.15 kg. (time, one second).

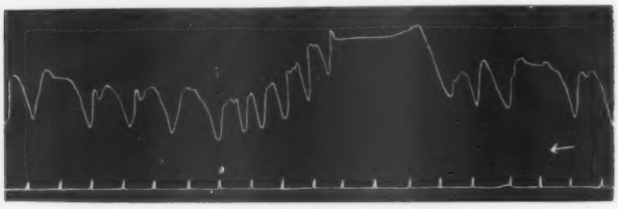

Fig. 33.—T. T., aged 2 months, weight, 2.5 kg. (time, one second).

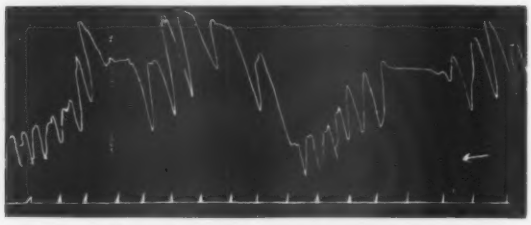

Fig. 34.—K. M., aged 3 weeks, weight, 2 kg. (time, one second).

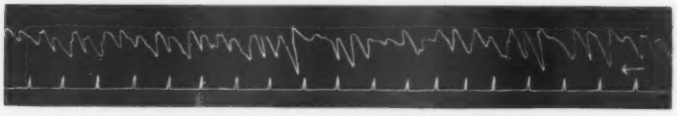

Fig. 35.—K. M., aged 5 months, weight, 3.1 kg. (time, one second).

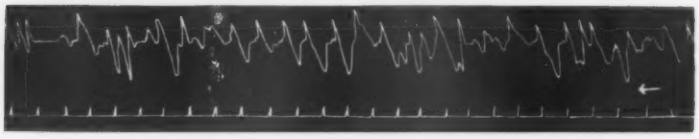

Fig. 36.—S. Y., aged 6 months, weight, 3.8 kg. (time, one second).

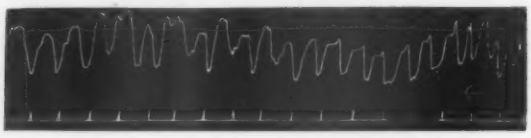

Fig. 37.—M. S., aged 4 months, weight, 3.95 kg. (time, one second).

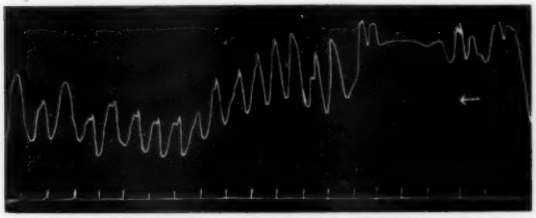

Fig. 38.—T. H., aged 1 month, weight, 2.01 kg. (time, one second).

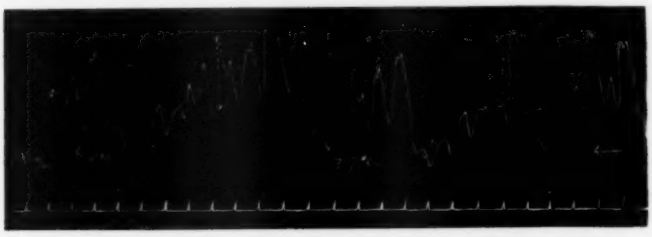

Fig. 39.—H. O., aged 5 months, with thrush (time, one second).

Fig. 40.—M. S., aged 2 months, with thrush (time, one second).

Fig. 41.—J. M., aged 4 months, with aphthae (time, one-fifth second).

Fig. 42.—M. N., aged 2 months, with aphthae (time, one second).

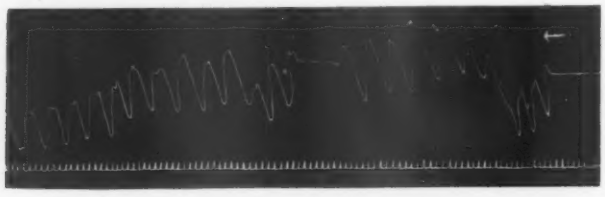

Fig. 43.—K. U., aged 2 months, with aphthae (time, one-fifth second).

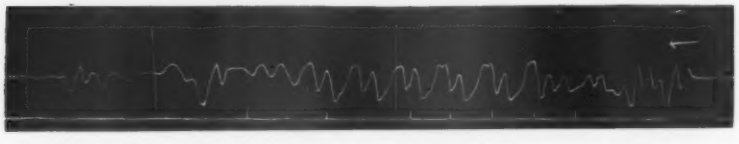

Fig. 44.—I. H., aged 3 weeks, with nasal catarrh (time, one second).

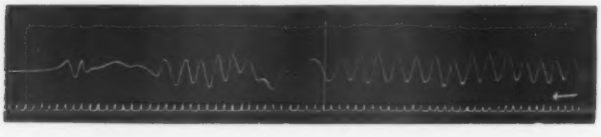

Fig. 45.—M. I., aged 3 months, with nasal catarrh (time, one-fifth second).

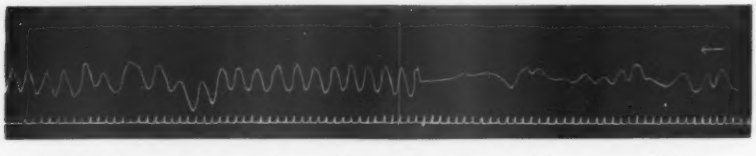

Fig. 46.—S. I., aged 5 months, with nasal catarrh (time, one-fifth second).

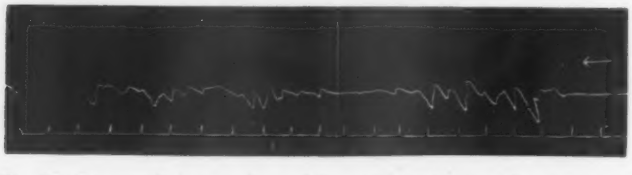

Fig. 47.—K. T., aged 4 months, with nasal catarrh (time, one second).

Fig. 48.—T. N., aged 3 months, with acute otitis (time, one second).

Fig. 49.—M. O., aged 2½ months, with acute otitis (time, one second).

Fig. 50.—K. K., aged 6 months, with acute otitis (time, one second).

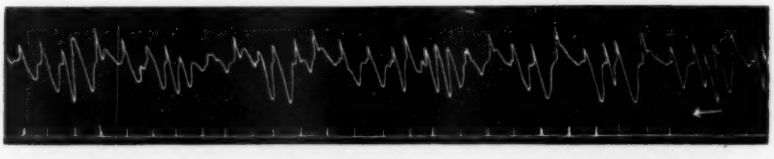

Fig. 51.—M. G., aged 1 month, with hereditary syphilis (time, one second).

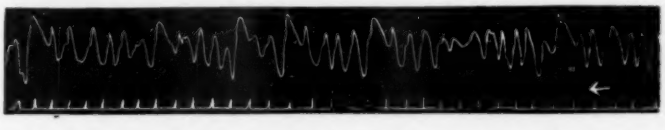

Fig. 52.—K. K., aged 2 months, with hereditary syphilis (time, one second).

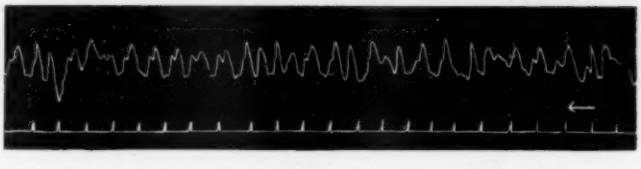

Fig. 53.—M. T., aged 3 months, with hereditary syphilis (time, one second).

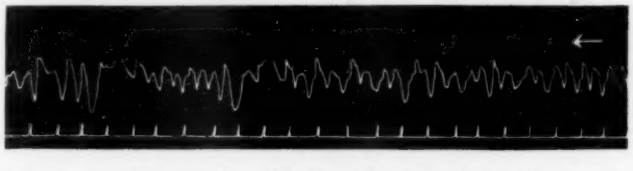

Fig. 54.—H. T., aged 1 month, with hereditary syphilis (time, one second).

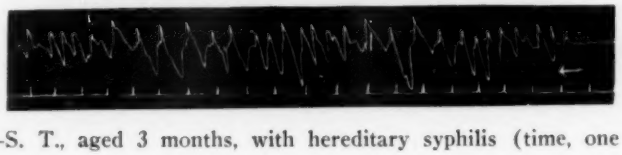

Fig. 55.—S. T., aged 3 months, with hereditary syphilis (time, one second).

Fig. 56.—I. K., aged 3 months, idiocy (time, one second).

Fig. 57.—M. N., aged 5 months, idiocy (time, one second).

Fig. 58.—O. K., aged 6 months, idiocy (time, one second).

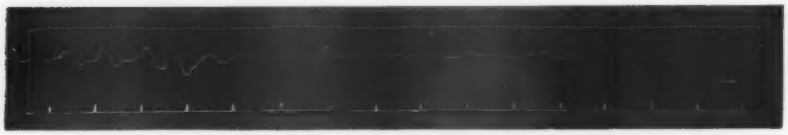

Fig. 59.—K. H., aged 5 months, idiocy (time, one second).

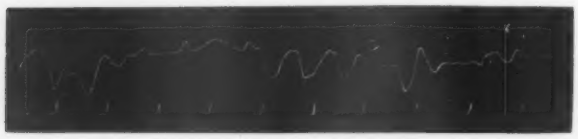

Fig. 60.—O. I., aged 5 months, with myxedema (time, one second).

Fig. 61.—O. I., after thyro-iodin treatment (time, one-fifth second).

Certain diseases in the mouth, such as thrush (Figs. 39 and 40) and aphthae (Figs. 41 to 43); diseases of the respiratory organs, such as nasal catarrh (Figs. 44 to 47); diseases of the ears, such as acute otitis (Figs. 48 to 50), all make the curved lines of suction irregular, but they become regular again as soon as the diseases are cured. An infant who is suffering from hereditary syphilis and whose nose is obstructed makes the most irregular curved lines of suction (Figs. 51 to 55).

It is an interesting fact to notice that idiots always make irregular curved lines of suction, probably because there are disorders in the coordination of muscles, which is necessary for suction (Figs. 56 to 59). In an infant who was suffering from myxedema I saw that the curved lines of suction were irregular (Fig. 60), but as soon as the psychical development improved after the thyro-iodin treatment was kept up, the lines became gradually regular (Fig. 61).

SUMMARY

1. The curved lines of suction made by infants in good health are always regular and never discontinued.

2. When an infant in good health sucks and swallows milk the time ratio of the two acts is 1 to 1, or rarely, 2 to 1.

3. In the case of a newborn baby, the curved lines of suction are discontinued now and then for physiologic reasons. In this case there is a certain pause between regular curved lines of suction.

4. Infants of premature birth or in atrophy make very irregular curved lines of suction, and often discontinue them, but the lines gradually become regular again when the state of nutrition improved.

5. Certain diseases of the mouth, nasal catarrh, and acute otitis, etc., make the curved lines of suction irregular, but they become regular again when the diseases are cured.

6. The curved lines of suction will become irregular when the temperature of milk is below 20 C. or above 40 C.

7. Idiots are unskilful in suction, and so the curved lines are always irregular.

I wish to take this opportunity to thank Prof. I. Hirai for his valuable suggestions in connection with this work.

Kyoto, Japan.

PROGRESS IN PEDIATRICS

REVIEW OF THE LITERATURE ON THE METABOLISM OF NORMAL INFANTS*

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BALTIMORE

Full reviews of the literature on the metabolism of infants under both normal and pathologic conditions appear in the recent textbooks of Langstein and Meyer,[1] and of Morse and Talbot.[2] Niemann[3] and Benedict and Talbot[4] present critical reviews of the literature on the respiratory exchange of infants, and Hellesen[5] reviews the entire subject of normal infant metabolism.

TOTAL ENERGY METABOLISM OF THE NEWLY BORN

Hasselbalch,[6] whose work except in Danish, has only recently become available, found that the amount of the infant's metabolism is to a very large extent dependent on muscular contractions, violent crying causing an increase in the total heat production of more than 100 per cent. At 32 C. and with the minimum muscular work the metabolism per kilogram of the newly born infant is hardly greater than that of the adult at complete rest. He observed a total heat production of as low as 30 calories per kilogram, calculated on the basis of twenty-four hours; it was seldom as great as 40 calories. Hasselbalch concluded from the high respiratory quotients observed with infants during the first hours of life that the metabolism depends chiefly and at times entirely on the oxidization of carbohydrates. The well-nourished infant, born at full term, possesses a store of carbohydrate (glycogen) in his organs, which is spent in the course of a few hours. As premature infants also possess a store of glycogen and show an exclusive metabolism of carbohydrates just after birth, Hasselbach states that there is every reason to suppose that the metabolism of the normal, well-nourished human fetus depends on the oxidization of carbohydrates.

* Submitted for publication May 31, 1916.

1. Langstein and Meyer: Säuglings Ernährung und Säuglingsstoffwechsel, Ed. 2, 1914, Wiesbaden.
2. Morse and Talbot: Diseases of Nutrition and Infant Feeding, 1915, New York.
3. Niemann: Ergebn. d. inn. Med. u. Kinderh., 1913, xi, 32.
4. Benedict and Talbot: Pub. Carnegie Inst., Wash., 1914, No. 201; ibid., 1915, No. 233; Am. Jour. Dis. Child., 1914, viii, 1.
5. Hellesen: Nord. med. Ark., 1915, xlviii, 1, 42.
6. Hasselbalch, Bibliot. f. Laeger, 1904, viii, 219, translated and appearing in publication No. 233, Carnegie Institute of Washington, 1915.

When the infant is fed with breast milk, the respiratory quotient shows that carbohydrate is the element most quickly utilized; it is completely metabolized within about one and a half hours after the meal. When the carbohydrate has been used up, as shown by a drop in the respiratory quotient, infants usually show evidences of hunger, such as vigorous sucking of the fingers and crying. When glucose is fed, the respiratory quotient gives no evidence of oxidization of carbohydrate until one-half hour after the feeding; the oxidization is, however, apparently completed within two and one half hours.

Benedict and Talbot[7] discuss critically Hasselbalch's work and suggest the presence of errors in his technic. They were unable to confirm Hasselbalch's observation that shortly after birth carbohydrates are exclusively utilized. Their results indicate that not more than two thirds of the total heat production results from the oxidization of carbohydrates. During the first day of life the average respiratory quotient corresponds to a metabolism in which only about one third of the energy comes from carbohydrate and two thirds from fat. The respiratory quotient is practically the same as that occurring during the first twenty-four hours of fasting in the normal human adult. After the first feeding of milk Benedict and Talbot observed very constantly a rise in the respiratory quotient, indicating the utilization of carbohydrate. Contrary to the findings of Hasselbalch, they found that the respiratory quotient was independent of the body weight, small infants having the same respiratory quotients as larger ones.

Benedict and Talbot[4] discuss critically Hasselbach's work and of life the total energy exchange during periods of rest varies from 32 to 52 calories per kilogram of body weight per twenty-four hours, with an average of 42 calories per kilogram. Approximately half of the infants studied gave energy quotients falling within 10 per cent. of this average value. The basal heat production, calculated on the basis of square meters of body surface, as determined by Lissauer's formula, was 612 calories. Two thirds of the infants studied showed values within 10 per cent. of this average. The extreme variations were from 459 to 732 calories per square meter of body surface per twenty-four hours. The metabolism during the first twenty-four hours of life is somewhat less than on subsequent days. Benedict and Talbot deny any close relationship between total metabolism and either the body surface or the body weight in the newly born. They explain the wide variations observed when the total metabolism is calculated in terms of square meters of body surface as due to a failure to consider the length of the child in the calculations. All formulas previously suggested for the determination of body surface, which ascribe the same surface area and therefore the same metabolism to a thin and a fat child of the same weight are necessarily incorrect. Benedict and

Talbot found that the energy exchange per square meter of surface bears a more or less definite relationship to body length. They found the total heat production to be from 11.9 to 13.4 calories per square meter of body surface per centimeter of length per twenty-four hours, the average being 12.65 calories. On this basis they suggest a formula for the calculation of the heat production of infants during the first week of life. The formula is as follows: Length in cm. $\times$ 12.65 $\times$ 10.3 $\times \sqrt[3]{Wt^2}$.

They give tables for the computation of the total caloric output for any infant on the basis of this formula. Using this formula in the study of the heat production of 105 newly born infants, they found that observed and calculated values for the total metabolism agreed within 6 per cent. in nearly every instance. The total metabolism calculated in this way is the basal, starving, resting metabolism. In any infant during twenty-four hours the actual requirement is greater, as in this computation no allowance is made for growth, for activity or for unabsorbed food. Benedict and Talbot, in accordance with previous observers, have noted a very marked influence of muscular activity on the total heat production. During violent crying they observed an increase as high as 211 per cent. The average increase in metabolism due to moderate activity was 65 per cent. The total metabolism is also increased by exposure to a low temperature. These authors suggest that on the basis of the whole twenty-four hours, 30 per cent. should be added to the basal heat production to allow for activity and that 10 per cent. should be added for the loss of food due to nonabsorption. In the light of these considerations they calculate the average daily energy requirement during the first week of life, including both the maintenance metabolism and the metabolism due to activity, to be approximately 62 calories per kilogram per twenty-four hours. This estimate allows no provision for growth.

TOTAL ENERGY METABOLISM OF OLDER INFANTS

Benedict and Talbot[4] have also studied the heat production of a group of thirty-seven infants varying in age from 19 days to 18 months. The infants were all approximately normal, although a number were below the average in weight for the age. They found the average basal resting heat production during the postabsorptive stage, that is, from one to one and one half hours after a feeding, to be 65 calories per kilogram of body weight. The extreme values observed were 44 and 88 calories per kilogram, respectively. These authors state that, "aside from a slight tendency for the total metabolism to be larger with increasing weight, no regular relationship exists with infants between the total heat production and the body weight, regardless of whether the body weight was actually found, computed from statis-

tics of average values for normal infants, or was the expected body weight based on the birth weight." Calculating the body surface by means of the several formulas of Meeh, Lissauer, and of Howland, they find the heat production to vary from 656 to 1,367 calories per square meter of body surface. They state on the basis of these findings that no constancy in relationship exists between body surface and total metabolism, at any rate when the body surface is computed by means of any of the formulas so far devised. They conclude that the extent of metabolism is determined neither by weight nor by surface area, but by the mass of active protoplasmic tissue, as suggested by Howland. They consider it likely that with normal infants of varying weight the active protoplasmic mass varies directly with the age. Excessive or deficient adipose tissue, representing relatively inactive protoplasmic mass, may cause a failure of agreement between the heat production calculated from the surface area and that actually measured. The apparent relationship that has been previously observed between the heat output and the body surface with normal or nearly normal individuals is explained on the basis that with such individuals a simple relationship exists between the body surface, blood volume, body weight, and the mass of active protoplasmic tissue. Benedict and Talbot determined further that in the infant the specific dynamic action of food is relatively slight, since they found practically the same heat production one hour after feeding and twenty-one hours after. The pulse rate, they find, is roughly proportional to the total metabolism as far as the same infant is concerned; but a difference in the pulse rate of any two infants does not necessarily indicate a proportional difference in metabolism, even when the infants are of the same age and weight. They do not believe the increased metabolism noted with increased pulse rate is due exclusively to the mere mechanical work of the circulation, but that the pulse rate is rather to be considered as an index of muscle and general tonus in the body.

Murlin and Hoobler[8] studied the total energy metabolism of ten hospital children ranging in age from two to twelve months and in nutritive condition from extreme marasmus to excessive weight. None of the children were acutely ill. The subjects were fed immediately before the observation; and slept a large part of the time they were in the calorimeter. The average heat production for the sleeping periods was 65 calories per kilogram of body weight, calculated on the basis of twenty-four hours. The extreme variations were from 60 to 84 calories, the highest heat production per kilogram being observed in the case of atrophic children and the lowest in the case of normal or overweight children. The average heat production calculated on the basis of surface area (Meeh's formula) was 950 calories per square

8. Murlin and Hoobler: Am. Jour. Dis. Child., 1915, ix, 81.

meter. The average deviation from the mean on the basis of weight for all the children studied was 12.1 per cent., on the basis of surface area 11 per cent. For the infants under 6 months the deviation on the basis of weight was less than on the basis of surface area. Murlin and Hoobler conclude that, if one takes into account the possible variations in the specific dynamic action of the food, the results must be taken as confirmatory of Rubner's law of surface area; they do not feel, however, that there is a sufficient reason for estimating the heat production on the basis of surface area rather than on the basis of weight. The pulse rate of infants of different ages, they found, could not be taken as a criterion of the extent of metabolism.

Niemann[8] observed a very constant heat production during the first year of life of from 900 to 1,000 calories per square meter of calculated body surface. Hellesen[5] found the resting heat production of a normal 5 months old infant to be 68 calories per kilogram of body weight, or 1,076 calories per square meter of calculated body surface. When a portion of the carbohydrate of the diet was replaced by an isodynamic amount of fat, the heat production increased 8.3 per cent. Schlossman,[9] on the other hand, observed an increase of 15 per cent. in the heat production of an infant as the result of a substitution of an isodynamic quantity of carbohydrate in place of part of the fat of the diet.

Frank and Niemann[10] found the total carbon dioxid production to be approximately 10 per cent. greater with artificial feeding than with breast feeding. They attributed this difference to the specific dynamic action of the proportionately larger amount of protein in the artificial mixture. Samelson,[11] however, determined the total caloric intake of normal twins of the same size and state of nutrition, the one being fed on artificial mixtures and the other on breast milk, and found a somewhat lower intake in the case of the artificially fed infant. The infants thrived equally well. The total intake, as determined by analysis of the food, was never greater than 100 calories per kilogram with either infant. Premature infants, however, fed on mixed breast milk consumed from 115 to 140 calories per kilogram.

Pritchard[12] states that the energy requirement of infants is exceedingly dependent on the character of the clothing and also on humidity and ventilation. The amount of time that the infant is allowed daily for the free use of the limbs also exerts a distinct influence on the total energy requirement. An infant warmly clothed and allowed very little exercise has a lower food requirement.

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9. Schlossmann: München. med. Wchnschr., 1913, ix, 285.
10. Frank, K., and Niemann: Charite-Ann., 1913, xxxvii, 94.
11. Samelson: Habilitationschrift, Strassburg. Springer, Berlin, 1913.
12. Pritchard, E.: Brit. Jour. Child. Dis., 1914, xi, 49.

METABOLISM DURING STARVATION

Schlossmann[13] and Schlossmann and Murschhauser[14] determined the effects of starvation on the metabolism of infants. Healthy infants were starved for from seventeen to seventy-two hours. They received water, salt and saccharin at the regular feeding intervals and seemed to experience no discomfort. Infants previously fed on artificial mixtures at first gained slightly in weight, then began to lose. There was, at the beginning of the fast, a decreased nitrogen elimination, which subsequently increased. Infants previously fed on breast milk, however, showed, from the beginning, an increased nitrogen elimination, but the total amount during the period of fasting was always less than in the case of the artificially fed infants. The feeding of a small amount of lactose invariably led to a marked diminution in the nitrogen output. The blood sugar content remained normal until near the end of the fasting period, when a slight fall occurred. Acetone and diacetic and beta-oxybutyric acid excretion began after twelve hours of starvation. The quantities excreted increased slowly at first, but later the excretion became as great as that of an adult fasting for the same length of time. The beta-oxybutyric acid excretion was always greater than the acetone excretion, but ran parallel to the latter. In every instance the administration of as much as 70 gm. of lactose per day prevented entirely the excretion of acetone bodies. Elimination of lactose from the diet resulted in a prompt return of the acetonuria. During the fasting periods the carbon dioxid production fell approximately 10 per cent. The total metabolism, calculated in terms of the different foodstuffs, showed that at the end of forty-eight hours fasting 1.74 gm. of protein, 2.95 gm. of carbohydrate and 4.47 gm. of fat were metabolized in the course of twenty-four hours. At the end of seventy-two hours the protein metabolism had increased to 2.24 gm., the carbohydrate had remained the same, 2.95 gm., while the fat consumed had fallen to 3.53 gm.. Infants fed on a high carbohydrate diet previous to the fast showed higher respiratory quotients than those fed on a high fat diet. The authors attributed this difference to the greater amount of stored-up glycogen used by the infants previously fed on carbohydrates. The respiratory quotients showed further that fat infants during starvation burned relatively more fat and less carbohydrate than thinner ones.

THE METABOLISM OF CARBOHYDRATES

Porter and Dunn[15] state that the addition of as much as 120 gm. of lactose to the feedings of infants with indigestion in the course of twenty-four hours does not lead to the excretion of a sufficient amount

13. Schlossmann: Vortrag geh. in d. deutsch. ges. f. Kinderh., 1913, ix, 24.
14. Schlossmann and Murschlauser: Biochem. Ztschr., 1913, lvi, 335. Schlossmann, M.: ibid., 1914, lviii, 483.
15. Porter and Dunn: Am. Jour. Dis. Child., 1915, x, 77.

of sugar in the urine to be determined quantitatively by the usual methods. On the basis of these experiments they urge the more frequent use of fair amounts of sugars in nutritional disorders.

Talbot and Hill[16] determined that the administration of a moderate amount of lactose in the diet increases nitrogen retention, but that large amounts, sufficient to cause loose stools, lead to a negative nitrogen balance. Small amounts of lactose have no effect on fat absorption; larger amounts decrease fat absorption and lead to the production of diarrhea, with acid stools and a negative mineral balance. Weill and Dufourt[17] confirm Talbot and Hill's results as to the effect of lactose on the reaction on the stools. They find, however, that the addition of as much as 25 gm. of glucose to the diet does not serve to make the stools acid. Carneiro[18] found that withdrawal of carbohydrates from the diet leads to a negative nitrogen balance and to a negative ash balance, chlorin being lost to a greater extent than any other ash constituent.

BLOOD SUGAR

Götzky,[19] using the Bang method, found the blood sugar during the first twelve days of life to average 0.085 per cent., at one month 0.095 per cent. and at one year 0.102 per cent. Bass,[20] using the Benedict-Lewis method for sugar determination in the blood, found in children from 2 to 14 years of age, sugar contents ranging from 0.072 to 0.113 per cent. These variations are approximately the same as those occurring in adults. Bergmark[21] reports that the feeding of maltose leads to a higher blood sugar than does the feeding of lactose, but that cane sugar causes a greater increase in blood sugar than either lactose or maltose. He believes that this difference in behavior is due to differences in intermediary metabolism rather than in the rate of absorption, since the increase in carbon dioxid production following the feeding of the different sugars does not run parallel to the increases in the blood sugar.

Schloss and Schroeder[22] have identified the reducing substance of the cerebrospinal fluid as glucose. The concentration in the cerebrospinal fluid varies from 0.05 to 0.134 per cent.

CARBOHYDRATE AND WATER METABOLISM

Niemann[23] finds that the addition of 40 to 50 gm. of carbohydrate to the diet of infants either in the form of milk sugar or cereal leads to a great decrease in the daily volume of the urine. Cane sugar, to

16. Talbot and Hill: Am. Jour. Dis. Child., 1914, viii, 218.
17. Weill and Dufourt: La Nourrisson, 1914, ii, 65.
18. Carneiro: Monatsch. f. Kinderh., 1913, xii, 333.
19. Götzky: Ztschr. f. Kinderh., 1913, ix, 44.
20. Bass: Am. Jour. Dis. Child., 1915, ix, 77.
21. Bergmark: Jahrb. f. Kinderh., 1914, lxxx, 373.
22. Schloss and Schroeder: Am. Jour. Dis. Child., 1916, xi, 1.
23. Niemann: Jahrb. f. Kinderh., 1915, lxxxii, 21.

the contrary, causes no diminution in the urinary output. Coincident with diminished urinary secretion, an increase in the body weight occurs. No increased water loss occurs by way of the intestinal tract or by the lungs, nor does Niemann consider it likely that there is an appreciable increase in the water loss by the expired air or the perspiration. He believes that a true water retention occurs, due to the carbohydrate. This water retention in some instances is sufficient to lead to a visible edema, although the greater part of the water retained is probably stored in the body in colloid combination with glycogen.

PROTEIN DIGESTION

Schackwitz[24] finds a sufficient amount of acid present in the gastric juice of infants to render peptic digestion of casein possible. He determined no essential difference between the gastric juice of artificially fed and of breast-fed infants. Finzio[25] claims that the gastric juice of normal infants after four hours' fast is capable of digesting casein. The juice removed at intervals of thirty, sixty, ninety, and 120 minutes after feedings of either woman's milk or cow's milk is also able to digest considerable quantities of milk protein. He concludes that the gastric juice of an infant is quite as effective in digesting the proteins of milk as is the adult gastric juice in digesting egg white. He draws attention to the work of previous observers who have found what they believe to be an insufficient amount of hydrochloric acid present in the gastric juice to activate pepsin, but maintains from the results of his experiments that free hydrochloric acid is not an essential for the peptic digestion of the proteins of milk.

PROTEIN ABSORPTION

A number of observers have endeavored to determine if protein can be absorbed through the intestinal wall without previous hydrolysis. Hayashi[26] administered from 15 to 20 gm. of raw egg albumin to normal infants, but failed to detect any albumin in the urine. Many infants suffering from eczema and from digestive disturbances, however, excreted protein in the urine after the ingestion of relatively small quantities of egg albumin.

Lawalschek,[27] by means of the precipitin reaction applied to the urine, determined that the intestinal tract of all infants under 10 days of age allows the passage of undigested foreign proteins. The permeability becomes less with age, but is increased during the course of nutritional disturbances. Modigliani and Benini[28] have confirmed the

24. Schackwitz: Monatsch. f. Kinderh., 1914, xiii, 73.
25. Finzio: La Pediatria, 1915, xxiii, 95, 168.
26. Hayashi: Monatschr. f. Kinderh., 1914, xii, 749.
27. Lawalschek, R.: Prag. med. Wchnschr., 1914, xl, 185.
28. Modigliani and Benini, Policlinico, Rome, December, 1915.

findings of Lawalschek as to the absorption of undigested protein in nutritional disorders. Schloss and Worthen[29] studied the absorption of unchanged protein by means of anaphylactic and precipitin reactions applied to the blood and urine. They found that when foreign protein is absorbed unchanged it appears in the blood sooner than in the urine, but that its presence may be detected in the urine for a longer time than in the blood. They found no evidence of absorption of whey protein from the intestinal tracts of the normal infants studied. Atrophic infants and those suffering from gastrointestinal disturbances, however, excreted whey protein in the urine. Egg protein they found at times to be absorbed unchanged by the normal infant's intestinal mucosa, when fed in large quantities, but not when moderate quantities were given. They state that in gastrointestinal disorders egg protein is frequently absorbed unchanged. The more severe the disorder, the greater the permeability of the gastro-intestinal tract. With improvement in the condition the permeability disappears. Of infants with eczema, 50 per cent. showed absorption of unchanged protein. Schloss and Worthen further attempted to demonstrate the presence of specific proteolytic enzymes in the blood serum. According to Abderhalden's hypothesis, the parenteral absorption of foreign proteins results in the formation of protective enzymes capable of hydrolyzing protein. These enzymes are presumably specific for the protein in question. Schloss and Worthen, following the technic advised by Abderhalden for the demonstration of specific proteolytic enzymes in the blood in pregnancy, were able to demonstrate enzymes capable of hydrolyzing milk and egg proteins in the blood of many normal infants. The occurrence of such enzymes, however, was more frequent in the blood of infants suffering from nutritional disorders. It is noteworthy that the blood from a number of infants who had never been fed egg proteins contained enzymes capable of hydrolyzing egg protein; this finding would seem to be a refutation of Abderhalden's hypothesis.

INTERMEDIARY METABOLISM OF PROTEIN

Hoobler[30] has studied the effect of low and high protein diets in infants and finds that protein when fed in excess causes an increase in the energy metabolism and that the increase is in proportion to the amount of protein oxidized and not to the amount of protein fed or retained in the body. Excessive feeding of protein does not reduce the amount of fat and carbohydrate metabolized, but the fat and carbohydrate need remains fairly constant and unless this minimal need is supplied in the food, the organism draws on its stored-up fat and glycogen, even when large amounts of protein are fed. When protein is fed in excess to infants a condition of stupor may supervene,

29. Schloss and Worthen: Am. Jour. Dis. Child., 1916, xi, 342.
30. Hoobler: Am. Jour. Dis. Child., 1915, x, 153.

which assumes serious proportions if such feeding is continued. The stupor gradually disappears as protein is reduced in the diet. The condition is considered by Hoobler to be a protein food injury and to constitute a clinical entity as definite in its symptomatology as that which arises from too prolonged use of diets high in carbohydrates. Hoobler claims that the protein need of a growing infant is completely supplied when 7 per cent. of its caloric need is furnished in the form of protein.

Cathcart and Green[31] found that in the metabolism of protein, the sulphur-containing groups are more quickly split off and eliminated than the rest of the molecule. Cohnheim[32] finds that completely hydrolyzed proteins, such as erepton, behave in the intestinal tract and in the intermediary metabolism exactly as unchanged protein.

Eisner[33] finds that protein metabolism, as determined by the neutral sulphur excretion, is disturbed when fats are eliminated from the diet, but is not at all influenced by changes in the carbohydrate intake.

Hellesen[5] finds that nitrogen retention in infants is less when the fat of the diet is increased and the carbohydrate decreased.

Cutter and Morse[34] found in a 2 year old infant that creatin elimination entirely ceased during a period of loss of weight dependent on vomiting, but again reappeared in the urine when the infant began to gain in weight. The creatinin elimination remained normal throughout. This finding is in contrast to the findings that have previously been reported on adults, in whom fasting and loss of weight is accompanied by increased creatin elimination and suggests a distinct difference in the intermediary protein metabolism of the infant and of the adult.

NITROGENOUS CONSTITUENTS OF THE BLOOD

Tileston and Comfort[35] found the nonprotein nitrogen and urea of the blood of children to be the same as that of adults. Schlutz and Pettibone[36] studied the nitrogenous compounds in the blood of newly born infants. They found the total nonprotein nitrogen varied from 23 to 44 mg., the urea nitrogen from 8 to 24 mg., ammonia nitrogen from 0.2 to 0.6 mg. and the amino-acid nitrogen as determined by the Van Slyke method, from 0.3 to 0.6 mg. per 100 gm. of blood. They draw attention to the fact that amino-acid nitrogen is frequently found in the blood in appreciable amounts even before the infant had received any food. They consider this finding as an indication of the passage of amino-acids from the maternal into the fetal blood. Nobécourt[37]

31. Cathcart and Green: Biochem. Jour., 1913, vii, 1.
32. Cohnheim: Ztsch. f. physiol. Chem., 1913, lxxxiv, 419.
33. Eisner: Dissertation Erlangen, 1913.
34. Cutter and Morse: Am. Jour. Dis. Child., 1916, xi, 331.
35. Tileston and Comfort: Am. Jour. Dis. Child., 1915, x, 278.
36. Schlutz and Pettibone: Am. Jour. Dis. Child., 1915, x, 206.
37. Nobécourt: Arch. de méd. d. enfants, 1914, xvi, 801.

determined the urea in the cerebrospinal fluid and found normally that the amount was never greater than 0.5 per cent. In nutritional disorders he observed increases in the urea content of the cerebrospinal fluid and considered this as evidence of increased protein destruction rather than of renal retention.

NITROGENOUS CONSTITUENTS OF THE STOOLS

Gamble[38] found the average amount of ammonia nitrogen in the stools of approximately normal infants to be 4.2 mg. per gram of dried stool, or 9 per cent. of the total nitrogen. The total amount of ammonia nitrogen increases with the protein intake. According to him, constipated stools contain the least ammonia, both relatively and absolutely. In malnutrition high amounts of ammonia were found. Urea was constantly found, although in very small amounts, the average urea nitrogen being 2 mg. per gram of dried stools. There seemed to be no constant relationship between the amounts of urea nitrogen and of ammonia nitrogen. Gamble suggests that the urea of the stools may not be entirely the result of excretion through the intestinal wall, but may be produced in the intestine by bacterial activity. His finding that the urea content of stools increases on standing would seem to lend support to this hypothesis.

Van Slyke, Courtney and Fales[39] state that the ammonia nitrogen of the stools makes up from 4 to 37 per cent. of the total nitrogen. They were unable to find any relationship between the amount of ammonia and the state of nutrition of the infant, or between acidity and the ammonia content of the stools. Urea was not found in 75 per cent. of the stools examined; when present the urea nitrogen made up from 1 to 5.6 per cent. of the total nitrogen. These authors do not believe that urea is secreted from the intestinal wall, as the urea was frequently absent in very loose stools. The amino-acid nitrogen made up from 1.8 to 17.6 per cent. of the total nitrogen. The stools of normal infants contained less amino-acid nitrogen than did those of infants with diarrhea.

Weill and Dufour[17] found that the feeding of relatively large amounts of protein to infants passing acid stools caused the stools to become neutral or alkaline in reaction.

FAT METABOLISM

Giffhorn[40] finds that the formation of soap stools may be prevented by the addition of whey to the diet.

Holt, Courtney and Fales[41] find that the fat content of the stools varies in most cases directly with the water content. In general, a

38. Gamble: Am. Jour. Dis. Child., 1915, ix, 519.
39. Van Slyke, Courtney and Fales: Am. Jour. Dis. Child., 1915, ix, 533.
40. Giffhorn: Jahrb. f. Kinderh., 1913, lxxviii, 531.
41. Holt, Courtney and Fales: Am. Jour. Dis. Child., 1915, ix, 213.

child losing twice as much water by the bowel is usually losing twice as much total fat. They observed, however, at times, a very high fat loss in dry, formed, soapy stools. The percentage of fat expressed in terms of fatty acid averaged 37.7 per cent. of the dried matter in very loose stools. The form of fat differed very much in the different types of the stools. In normal pasty stools the soap fats were present in larger amounts than neutral fat. In loose stools the ratio was reversed; in some very loose stools soaps were entirely absent, the neutral fat being at the same time greatly increased.

Hellesen[5] finds that when fat is substituted for an isodynamic amount of carbohydrate in the diet, marked alterations occur in the total heat production and in the metabolism of protein, mineral matter and water. These alterations are discussed elsewhere in this review.

MINERAL METABOLISM

Holt, Courtney and Fales[41] find that under normal conditions 40 per cent. of the total ash taken in cow's milk is lost in the stools. This is chiefly calcium phosphate. In loose stools as much as 84 per cent. of the intake may be lost, the great increase being made up of salts other than calcium phosphate. Chlorin, potassium, and sodium were found normally present in stools in relatively small amounts, but in large amounts in the urine. In loose stools there was an enormous increase in the quantity of these elements and a corresponding reduction in the amount eliminated by the urine. The increased excretion by the bowel, however, was so great that there was observed an actual negative balance of sodium and potassium.

Courtney and Fales[42] found that after injection of magnesium sulphate, subcutaneously, a very small amount of the magnesium was eliminated by the way of the bowels. The greater part appeared in the urine within twenty-four hours. None appeared on subsequent days. The sulphate portion of the molecule was immediately and completely excreted in the urine. Courtney and Fales do not believe that there is any danger of a cumulative effect of magnesium sulphate following repeated injections.

Bosworth, Bowditch and Ragle[43] studied the effects of varying the mineral intake by increasing or decreasing the whey of the food. They found that when the whey was decreased a less acid urine was secreted. The inorganic phosphates of the urine were decreased and the chlorid completely disappeared. There was a rise in the ammonia coefficient in the urine, due, as they believed, to the lack of bases in the food, as they found no increase in the production of acetone bodies. The infants studied lost weight during the time that they were fed on the diets poor in whey. The authors do not believe that the loss in weight

42. Courtney and Fales: Am. Jour. Dis. Child., 1915, ix, 318.
43. Bosworth, Bowditch and Ragle: Am. Jour. Dis. Child., 1915, ix, 120.

can be explained on any other ground than on that of mineral deficiency.

Kaminer and Mayerhofer[44] found that the inorganic phosphate excretion in the urine of infants increases during digestive disturbances and also following an increase in the concentration of the food, after the addition of sugar or cereal and on changing from breast milk to artificial feeding. Knox and Tracy[45] confirmed Kaminer and Myerhofer's findings as to the greater excretion of the phosphates in the urine of the artificially fed infants. They do not believe, however, that any conclusions can be drawn as to the nutritional disturbances from the urinary phosphate excretion.

Peiser[46] found an increase in the phosphorus and sulphur elimination by way of the bowel and a decreased elimination by the urine, when protein milk was substituted for breast milk in the feeding of a normal infant, and attributes the increased sulphur and phosphorus of the stools to a failure of absorption. Hellesen[5] finds that on diminishing the carbohydrate in the food of an infant and substituting an isodynamic quantity of fat, absorption of mineral matter from the intestinal tract is somewhat less, the absorption of calcium being affected more than that of the other inorganic constituents of the food. Ash retention is much less on the diet rich in fat, there being a marked increase in excretion of mineral matter by the urine. The loss of sodium in the urine is four times as great as with the low fat diet and is actually greater than the amount ingested. Smaller amounts of potassium, of calcium and of chlorin are retained. The retention of magnesium and of phosphoric acid is about the same with each diet.

WATER METABOLISM

A number of investigators have studied the water balance of infants. Benestad[47] attributes the loss of weight of newly born infants to disturbances in the water metabolism. Lederer[48] determined the water content of the blood of infants by a micromethod. He found that the blood in a normal breast fed infant at birth has a low water content; the water increases rapidly during two or three months, reaching a maximum at the middle of the third month. After this time a gradual but slow drying out occurs. He draws attention to the fact that the increase in the water content of the blood runs parallel with the rapid increase in water intake during the first three months.

44. Kaminer and Mayerhofer: Ztschr. f. Kinderh., 1913, viii, 24.
45. Knox and Tracy: Am. Jour. Dis. Child., 1914, vii, 409.
46. Peiser: Jahrb. f. Kinderh., 1915, xxi, 437.
47. Benestad, G.: Jahrb. f. Kinderh., 1914, lxxx, 21.
48. Lederer: Ztschr. f. ang. Anat. u. Konst., 1914, i, 298.

Infants fed on whole milk dilutions show a greater water content of the blood and a decreased physiologic drying out. In eczema he frequently observed rapidly occurring fluctuations in the water content of the blood. Hellesen[5] finds a negative water balance following the substitution of fat for a portion of the carbohydrate of the diet of an infant.

Widmer[49] finds that when the total fluid intake, including the water of solid food, is reduced to 65 gm. per kilogram, no unfavorable symptoms appear and infants from 1 to 2 years old continue to thrive. He considers 65 gm. per kilogram to be the minimum water requirement. When the water intake is increased to 110 gm. per kilogram, disturbances in weight and nutrition frequently occur. He considers the optimal water intake to be 85 gm. per kilogram and states that too much water leads to nutritional disturbances, especially rickets, tetany and eczema.

Niemann[3] finds the water vapor output of the body to be roughly proportional to body weight and not to surface area.

ACETONE BODIES

Veeder and Johnson[50] find small amounts of ketones (presumably acetone) and beta-oxybutyric acid present in the urine of normal children, even when their caloric requirements are fully covered by the diet. The amount varies from 20 to 100 mg., expressed in terms of acetone in twenty-four hours. Age, sex and body weight of the child apparently have no effect on the total amount excreted. The amount of beta-oxybutyric acid excreted is, as a rule, greater than the amount of acetone. They consider the large amount of acetone bodies in the urine of children on restricted diet to be due to an increase of substances normally present, rather than to the appearance of abnormal substances. Veeder and Johnson's results show the fallacy of the common belief, based on the incorrect interpretation of qualitative tests, that acetone appears in the urine in larger amounts than oxybutyric acid and that oxybutyric acid excretion is an evidence of a severe metabolic derangement.

Marriott[51] finds in the blood of normal children from 0.5 to 1.1 mg. of acetone and diacetic acid and 1.4 to 4.4 mg. of oxybutyric acid, expressed in terms of acetone per 100 gm. of blood, and emphasizes the frequent disproportion between the amounts of acetone substances in the blood and the amounts in the urine.

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49. Widmer: Jahrb. f. Kinderh., 1916, lxxxiii, 177.
50. Veeder and Johnson: Am. Jour. Dis. Child., 1916, xi, 245.
51. Marriott: Jour. Biol. Chem., 1914, xviii, 507.

OXALIC ACID

Sedgwick[52] finds that newly born infants excrete as much as 9 mg. of oxalic acid per day. The amount is relatively and at times absolutely greater than the excretion of oxalic acid by adults.

PSYCHIC FACTORS AND TEMPERATURE

Birk[53] emphasizes the influence of psychic factors on the metabolism and cites cases of children on the same diet thriving well or poorly depending on the nurse in charge. He explains "hospitalism" on the psychic basis. McClure and Sauer[54] find that an infant with ordinary light clothing in a room at a temperature of 31 C. is practically incapable of losing heat by either conduction or radiation. Experiments with puppies clothed in flannel and subjected to similar temperatures indicate that this failure of heat loss may lead to severe symptoms or even to a fatal termination.

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52. Sedgwick, J. P.: Am. Jour. Dis. Child., 1915, x, 414.
53. Birk, W.: Monatschr. f. Kinderh., 1913, xii, 1.
54. McClure and Sauer: Am. Jour. Dis. Child., 1915, ix, 490; Ibid., x, 425.

CURRENT PEDIATRIC LITERATURE

BACTERIOLOGY AND PATHOLOGY

Colon Bacillus, Recovery of, from Spinal Fluid of Five Months' Old Infant.—M. Michael.
Arch. Pediat., April, 1916.

METABOLISM AND NUTRITION

Development, Defective, Pathologic Physiology of Debility and, in Infants.—P. Noblécourt.
Arch. de méd. des enf., April, 1916.

Feeding, Infant, Short History of.—H. R. Mixsell.
Arch. Pediat., April, 1916.

Feeding, Infant, Some Common Errors in.—G. E. Zimmerman.
Journal-Lancet, May 1, 1916.

Infants, Disturbances in, from Unbalanced Proportions of Elements of Food Otherwise Suitable in Composition and Quantity.—G. Bessau.
Monatschr. f. Kinderh., xiii, No. 10, 1916.

Metabolism of Children, Studies in. I.—The Excretion of Creatinin and of Creatin in Acute Nephritis.—Irving S. Cutter and Max Morse.
Am. Jour. Dis. Child., May, 1916.

Metabolism of Children, Studies in. II.—Creatin Retention in Marasmus.—Irving S. Cutter and Max Morse.
Am. Jour. Dis. Child., May, 1916.

Protein, Undigested, the Permeability of the Gastro-Enteric Tract of Infants to.—Oscar M. Schloss and Thacher W. Worthen.
Am. Jour. Dis. Child., May, 1916.

Rachitis in Palermo.—S. Maggiore.
Pediatria, Naples, March, 1916.

DISEASES OF THE NEW-BORN

Bile Ducts, Congenital Obliteration of the. Diagnosis and Suggestions for Treatment.—James B. Holmes.
Am. Jour. Dis. Child., June, 1916.

Jaundice from Congenital Obliteration of Bile Duct.—R. Marinucci.
Pediatria, Naples, March, 1916.

Outgrowth, Congenital Cutaneous, Case of.—D. M. Greig.
Edinburgh Med. Jour., May, 1916.

Ophthalmia Neonatorum.—G. H. Thompson.
Boston Med. and Surg. Jour., May 25, 1916.

Pylorus, Stenosis of the, Operative Treatment of Congenital.—H. K. Hirschfeld.
Pediatria, Naples, May, 1916.

Talipes Valgus, Congenital.—H. C. Slomann.
Ugesk. f. Laeger, April 20, 1916.

ACUTE INFECTIOUS DISEASES

Diphtheria in Children, Early Serum Treatment of.—F. C. Neff.
Kansas Med. Soc. Jour., May, 1916.

Diphtheria in Cleveland; Diphtheria Carriers.—R. G. Perkins.
Jour. Infect. Dis., June, 1916.

Diphtheria, Diphtheria Bacilli not Found Invariably in.—E. Gomes.
Brazil-med., April 8, 1916.

Diphtheria Immunity; Its Determination by Schick Test.—W. H. Park and A. Zingher.
Am. Jour. Pub. Health, May, 1916.

Diphtheria, Laryngeal, Tracheotomy and Intubation in.—A. Franchini.
Gazz. d. osp., April 20, 1916.

Diphtheria, Schick Test for Immunity to.—G. Bessau and J. Schwenke.
Monatschr. f. Kinderh., xiii, No. 9, 1916.

Infectious Diseases, Prophylaxis of Spread of.—G.-H. Lemoine.
Presse méd., May 4, 1916.

Malaria in Malarial Countries, to Protect Schoolchildren Against.—E. Cacace.
Semana méd., March 9, 1916.

Measles, Concealed.—R. Opdyke.
New York Med. Jour., May 20, 1916.

Measles, Scarlet Fever and Other Infections, Experiences with Ethylhydrocuprein in the Treatment of.—Arthur D. Hirschfelder and Frederic W. Schultz.
Am. Jour. Dis. Child., May, 1916.

Measles, Some Important Factors Affecting Incidence of, and Fatality Therefrom.—J. G. Wilson.
Arch. Pediat., April, 1916.

Rheumatism in Children, Acute Articular.—A. S. Brady.
Kentucky Med. Jour., May, 1916.

Smallpox, Differential Diagnosis of.—A. Snoek.
Nederl. Tijdschr. v. Geneesk., March 25, 1916.

Vaccines, Typhoid, Agglutinins in the Blood of Children After Injection of.—P. S. Medovikoff.
Russk. Vrach, xv, No. 10, 1916.

Whooping Cough, Treatment of, by Subcutaneous Injection of Extract of Patient's Sputum.—J. Melfi.
Semana méd., March 9, 1916.

TUBERCULOSIS AND SYPHILIS

Syphilis, Inherited, Laudau Reaction in.—L. Chiaravalloti.
Pediatria, Naples, March, 1916.

Tuberculous Infection in Children.—H. W. Dana.
Boston Med. and Surg. Jour., May 25, 1916.

Tuberculosis, Localized Forms of, in Young Infants.—Combe.
Le Nourrisson, March, 1916.

Wassermann Test, Blood Serum More Reliable than Milk for, for Wet-Nurses.—Merisset.
Le Nourrisson, March, 1916.

Wassermann Reaction in Mental Deficiency in Children, Value of. Study of Seventy-Eight Cases.—A. Gordon.
Arch. Pediat., April, 1916.

GASTRO-INTESTINAL SYSTEM

Acidosis Occurring with Diarrhea.—John Howland and W. McKim Marriott.
Am. Jour. Dis. Child., May, 1916.

Diarrhea in Childhood, Classification and Treatment of.—F. H. Lamb.
Ohio State Med. Jour., May, 1916.

Diarrhea in Infants, Bacilli Dysenteriae as Cause of Infections.—C. Ten Broeck and F. G. Norbury.
Boston Med. and Surg. Jour., June 1, 1916.

Diarrhea and Vomiting of Children, Experimental Investigation on—E. Mellanby.
Quart. Jour. Med., April, 1916.

Omentum as Factor in Pericolitis.—P. Descomps.
Rev. de chir., January, 1916.

RESPIRATORY SYSTEM

Pneumonia, Results of Open Air Treatment of, in Children.—A. R. Cunningham.
Boston Med. and Surg. Jour., May 25, 1916.

BLOOD AND CIRCULATORY SYSTEM

Addison's Disease in Girl of Ten.—G. Rutelli.
Pediatria, Naples, May, 1916.

Blood, the Nonprotein Nitrogenous Constituents of the, and the Phenolsulphonephthaliein Test in Children.—Jerome S. Leopold and Adolph Bernhard.
Am. Jour. Dis. Child., June, 1916.

Hemoglobin Percentage, Determination of.—E. Meulengracht.
Ugesk. f. Laeger, March 23, 1916.

Vascular Disease in Young; Report of Cases.—C. W. Chapman.
Brit. Jour. Child. Dis., April, 1916.

NERVOUS SYSTEM

Abscesses, Multiple, of Brain in Infancy, Case of.—J. B. Holmes.
Arch. Int. Med., May, 1916.

Epilepsy, Interval Leukocyte Picture in.—A. Schoondermark.
Nederl. Tijdschr. v. Geneesk., March 25, 1916.

Feebleminded and Public Schools.—C. G. Fraser.
Pub. Health Jour., May, 1916.

Hydrocephalus in Childhood, Anatomic Cause of Frequency of.—W. Browning.
Med. Rec., New York, May 27, 1916.

Meningitis, Cerebrospinal, Epidemic.—J. P. Bijl and N. M. Eykel.
Nederl. Tijdschr. v. Geneesk., April 15, 1916.

Meningitis, Epidemic Cerebrospinal, as Seen in Anglo-Egyptian Sudan.— A. J. Chalmers and W. R. O'Farrell.
Jour. Trop. Med. May 1, 1916.

Meningitis, "Partitioned-Off," Treatment of.—A. Netter.
Bull. de l'Acad. de méd., March 21, 1916.

Neurology in Childhood, Review of for 1914-1915.—A. B. Schwartz.
Am. Jour. Dis. Child., May, 1916.

Paralysis, Two Cases of Obstetrical, Involving Only the Musculospiral Nerve.—L. Howard Smith.
Am. Jour. Dis. Child., May, 1916.

Poliomyelitis, Subacute Anterior.—A. W. Harrington and J. H. Teacher.
Glasgow Med. Jour., May, 1916.

Pseudotetanus, in Boy Under Two, Case of.—A. Hirsch.
Monatschr. f. Kinderh., xiii, No. 10, 1916.

Spasmophilia in Children Over Three.—H. A. Stheeman.
Nederl. Tijdschr. v. Geneesk, April 1, 1916.

Speech Disorders, Common, of Childhood.—J. Priestley.
Brit. Jour. Child. Dis., April, 1916.

GENITO-URINARY SYSTEM

Alkaptonuria from Birth in Girl of Six.—S. Maggiore.
Pediatria, Naples, April, 1916.

Anuria, Prolonged, with Few Symptoms, Report of a Case of.—F. E. Clough.
Am. Jour. Dis. Child., May, 1916.

Enuresis, Reflex, Treatment of.—F. A. Deluca.
Semana med., xxiii, No. 3, 1916.

Nephritis Without Albuminuria.—J. P. Parkinson.
Brit. Jour. Child. Dis., May, 1916.

Nephritis, Chronic, in Child, Report of a Case of Nonparasitic Chyluria. With Necropsy.—A. Hymanson.
Am. Jour. Dis. Child., June, 1916.

Nephritis, Epinephrin in Treatment of.—G. B. Borelli.
Policlinico, Rome, April 30, 1916.

OSSEOUS SYSTEM

Clavicle, Fractured, Immobilizing with Rod Passed Through Elbows Behind the Back.—Lüthi.
Corr.-Bl. f. schweiz. Aerzte, March 25, 1916.

SKIN AND APPENDAGES

Eczema, Cutaneous Reaction from Proteins in.—Kenneth D. Blackfan.
Am. Jour. Dis. Child., June, 1916.

Psoriasis Brought on by Fright or Trauma.—M. Gaucher and R. Klein.
Paris méd., May 6, 1916.

Ringworm in Children.—E. L. Oliver.
Boston Med. and Surg. Jour., May 25, 1916.

Streptococcus Infection, Skin Manifestations With.—A. B. Schwartz.
Am. Jour. Dis. Child., June, 1916.

EYE, EAR, NOSE AND THROAT

Hearing Tests in School Children.—M. Yearsley.
Brit. Jour. Child. Dis., May, 1916.

Keratomalacia, Experimental, from Unbalanced Diet.—E. Freise, M. Goldschmidt and A. Frank.
Monatschr. f. Kinderh., xiii, No. 9, 1916.

Microphthalmus, Congenital Bilateral, with Cysts in Lower Lids and Left Harelip.—H. Weve.
Nederl. Tijdschr. v. Geneesk., March 25, 1916.

Septum in Children, Results of Submucous Resection of.—C. H. Hayton.
Jour. Laryngol., Rhinol. and Otol., April, 1916.

Tonsillitis of Gastro-Intestinal Origin.—E. Döbeli.
Corr.-Bl. f. schweiz. Aerzte, April 8, 1916.

SURGERY AND ORTHOPEDICS

Anus, Imperforate.—E. T. Campbell.
Florida Med. Assn. Jour., May, 1916.

Surgery of Infants and Small Children.—C. G. Buford.
Surg., Gynec. and Obst., May, 1915.

THERAPEUTICS

Abscesses, Rapid Healing of, in the Neck Without Scars Under Filiform Drainage.—H. Chaput.
Paris méd., April 22, 1916.

Heliotherapy, Prophylactic.—L. Jeanneret.
Rev. méd. de la Suisse romande, April, 1916.

Serotherapy and Anaphylaxis in Children.—J. Comby.
Arch. de méd. des enf., April, 1916.

Tetanus, Serotherapy of, Recovery Under.—G. Etienne.
Paris méd., April 29, 1916.

MISCELLANEOUS

Abscesses, Otogenous Subperiosteal, in Temporal Region; Thirty-One Cases.—R. Lund.
Ugesk. f. Læger, March 30, 1916.

Autointoxication, Auto, in Infancy and Childhood; Report of Cases.—J. L. Morse.
Boston Med. and Surg. Jour., April 20, 1916.

Babies' Class, Report of Work Done in, from Oct. 1, 1914, to Sept. 30, 1915.—E. L. Coolidge.
Bull. Lying-In Hosp., April, 1916.

Birth Rate, Declining, and Measures for Infant Welfare.—H. W. Methorst.
Nederl. Tijdschr. v. Geneesk., April 8, 1916.

Child Welfare.—J. Thomson.
Pub. Health Jour., April, 1916.

Criminal Boy. Observations Based on One Hundred and Twelve Cases.—W. O. Krohn.
Illinois Med. Jour., May, 1916.

Crippled and Deformed Children, Indigent, Advantage of State Hospital for, in Advancement of Orthopedic Surgery in State.—A. J. Gillette.
Am. Jour. Orthop. Surg., May, 1916.

Diseases, Children's, a Review.—H. Thursfield.
Practitioner, London, April, 1916.

Dyspituitarism in Girl, Aged Fifteen Years, Case of.—S. Stephenson.
Brit. Jour. Child. Dis., May, 1916.

Glands not Normally Palpable in Infants.—C. Coerper.
Monatschr. f. Kinderh., xiii, No. 10, 1916.

Lymphogranulomatosis in Boy of Five, with Necropsy.—A. F. Canelli.
Pediatria, Naples, April, 1916.

Morbidity and Mortality from Certain Communicable Diseases of Childhood as Influenced by Public Health Control.—B. F. Royer.
Pennsylvania Med. Jour., March, 1916.

Mortality, Infantile, and Relative Practical Value of Measures Directed to Its Prevention.—S. G. Moore.
Lancet, London, April 22, 1916.

Mortality, Infantile, and Relative Practical Value of Measures Directed to Its Prevention.—S. G. Moore.
Lancet, London, April 29, 1916.

Mortality, Infantile, and Relative Practical Value of Measures Directed to Its Prevention.—S. G. Moore.
Lancet, London, May 6, 1916.

Mortality, the Pediatrician in the Campaign Against Infant.—T. D. Roumianzeff.
Russk. Vrach, xv, No. 7, 1916.

Pediatrics as Specialty in Smaller Cities.—A. C. Eastman.
Boston Med. and Surg. Jour., May 25, 1916.

Proprietaries, Some Aspects of the Home Use of, With Children. T. C. Merrill.
Am. Jour. Pub. Health, May, 1916.

Protozoa, Ultraviolet Rays Check Proliferating Power of.—F. Porcelli-Titone.
Pediatria, Naples, March, 1916.

Schools, Medical Inspection of.—E. A. North.
Kentucky Med. Jour., May, 1916.

School, Open-Air, Movement.—P. L. Benjamin.
Journal-Lancet, May 1, 1916.

Schools, Rural, Sanitary Conditions in.—T. J. McNally.
Pub. Health Jour., April, 1916.

Sputum, Laryngoscope Mirror as Aid in Obtaining for Examination.—G. Rosenthal.
Paris méd., April 8, 1916.

Sterilization of Milk Without Heat not Practicable to Date.—A. B. Marfan.
Le Nourrisson, March, 1916.

Thorax, Roentgenography of, in Children.—J. S. Fowler.
Edinburgh Med. Jour., May, 1916.

Training Babies.—L. W. Elias.
South. Med. Jour., April, 1916.

Triplets, Eclampsia with, Two of Children United, Case of.—R. Jardine.
Lancet, London, April 1, 1916.

Weaning.—J. R. Snyder.
South. Med. Jour., April, 1916.